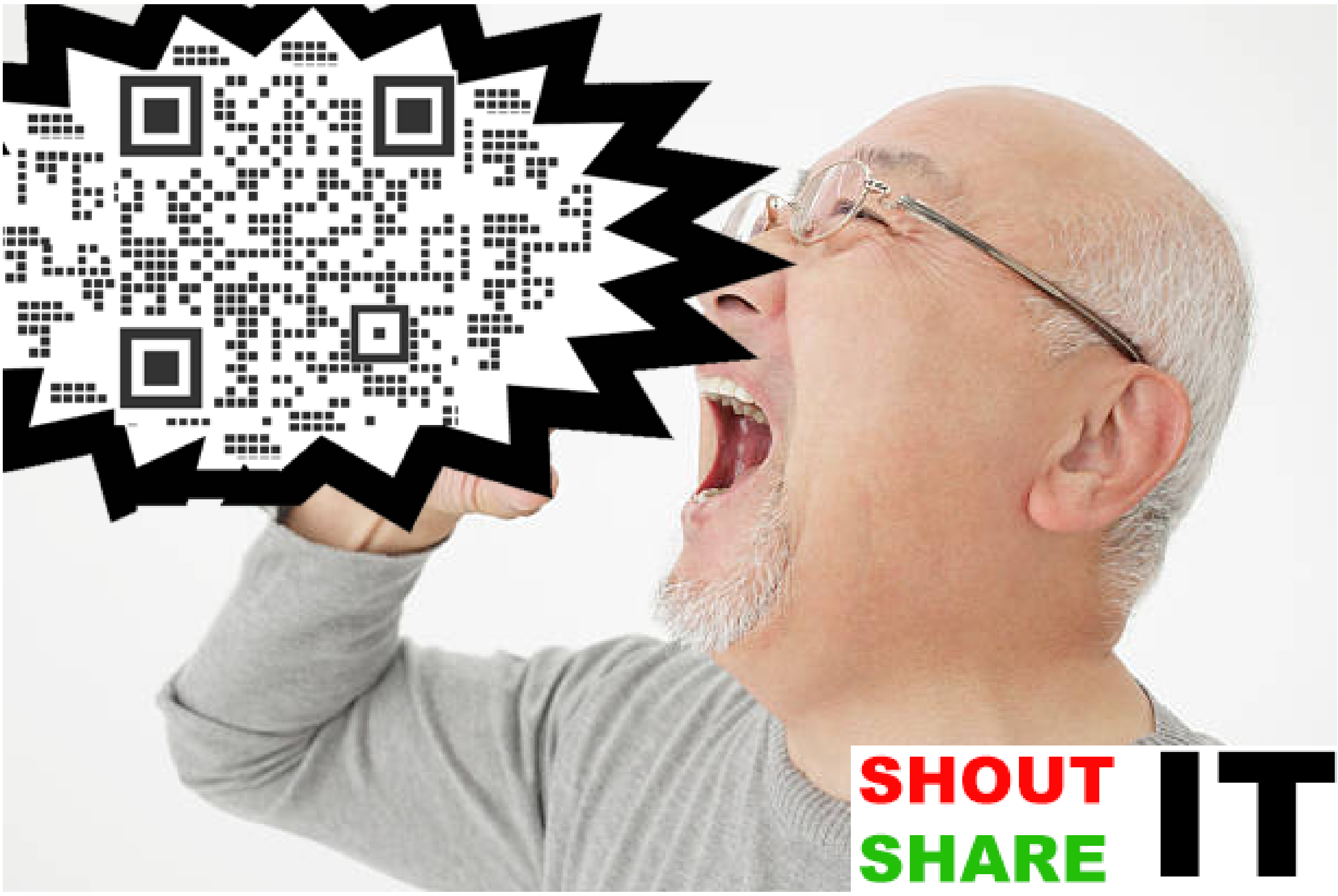
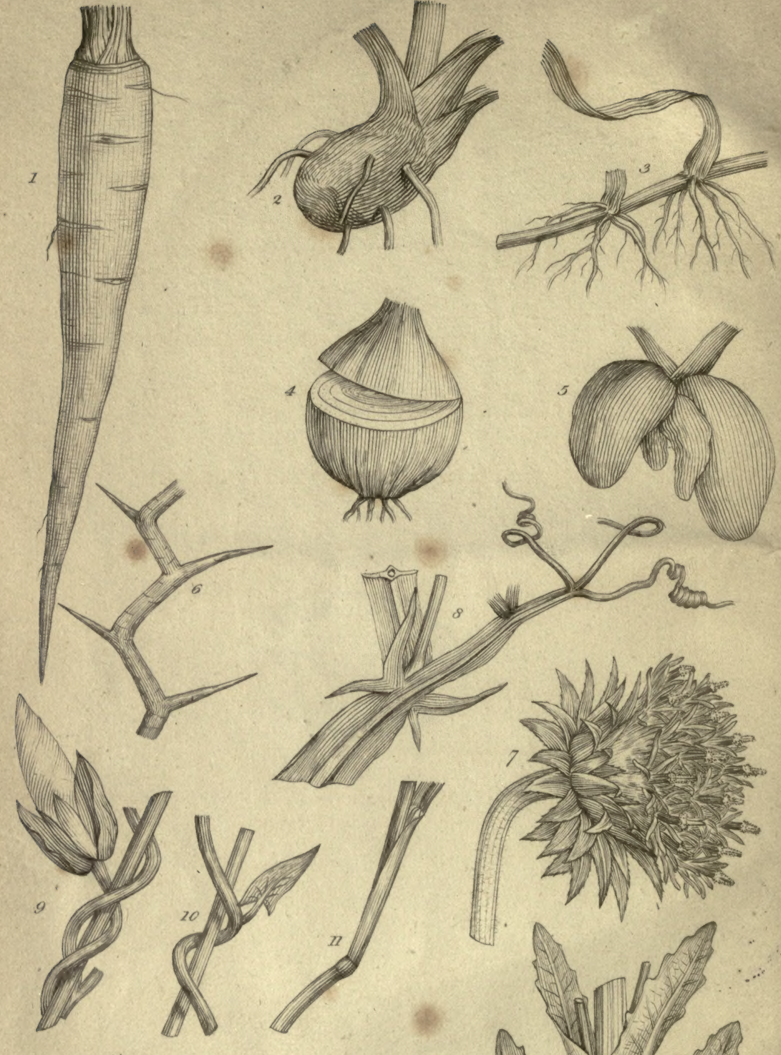

SHOUT
SHARE
IT

UNIVERSITY OF CALIFORNIA
ANDREW
SMITH
HALLIDIE:
REGENT
1868 1901

444
K28

BIOLOGY
LIBRARY
G

HALLIDIE LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA


1
2
3
4
5
6
7
8
9
10
11
12
13
14

Drawn & Engraved by Sowerby, for Baldwin, Cradock & Joy, April, 1816.

A

SYSTEM

OF

PHYSIOLOGICAL BOTANY,

BY

THE REV. P. KEITH, F. L. S.

VICAR OF BETHERSDEN, KENT; AND PERPETUAL CURATE
OF MARR, YORKSHIRE.

Illustrated by Nine Engravings.

IN TWO VOLUMES.

Verè scire est per causas scire.
BACON.

HALLIDIE LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

VOL. I.

LONDON:

PRINTED FOR BALDWIN, CRADOCK, AND JOY,
47, PATERNOSTER ROW;
W. BLACKWOOD, EDINBURGH; AND J. CUMMING, DUBLIN.

1816.

K42
V.1

BIOLOGY
LIBRARY
G

A. S. Hallidie

C. Baldwin, Printer,
New Bridge-street, London.

TO

THE LADY FRANCES DOUGLAS.

MADAM,

IF the knowledge of the economy of vegetation shall prove to be at all advanced or facilitated by the arrangements or investigations instituted in the following Work, it is owing to the influence of your Ladyship's counsel by which my attention was originally directed to the study of plants. On this account I have been solicitous to dedicate the Work to your Ladyship, as well as on account of the opportunity it affords me of expressing myself in acknowledgment of the kind patronage you have hitherto been pleased to extend to me, and in commendation of the laudable partiality you have always shown to botanical pursuits. This I regard as appearing not merely in your own individual studies, but in your directing the early studies of a young and dear family, whose education you have so ably and affectionately superintended, and whose incipient

103982

progress in the pleasing paths of Systematic Botany, it was my original wish to facilitate. But although that wish has been disappointed by the intrusion of a multiplicity of obstacles, and ultimate abandonment of my original plan, still it is within the scope of the plan now adopted to facilitate the study of Systematic Botany, at least in as much as it is preparatory to that of Physiological Botany, and thus legitimately to connect and elucidate the two grand departments of the study of Plants. It will readily be admitted that my undertaking has been laudable; and if I have succeeded in the execution of it so as to merit the approbation of your Ladyship, I shall be encouraged to hope that the result of my labours is not altogether unworthy of the notice of the public.

I have the honour to be,

Madam,

Your Ladyship's most obedient and
most obliged Servant

P. KEITH.

CONTENTS OF VOL. I.

Page

INTRODUCTION 1

BOOK I.

Of the External Structure of Vegetables 29
Part I. Perfect Plants 31
  Chap. I. Conservative Organs 32
    Sect. I. The Root 33
      II. The Trunk 42
      III. The Branches 48
      IV. The Leaf 51
      V. The Frond 60
  Chap. II. Conservative Appendages 61
    Sect. I. Gems 61
      II. Glands 67
      III. Tendrils 70
      IV. The Stipulæ 72
      V. Ramenta 74
      VI. Armature 76
      VII. Pubescence 79
      VIII. Anomalies 82
  Chap. III. Reproductive Organs 84
    Sect. I. The Flower 84
      II. The Flower Stalk 125
      III. The Receptable 128
      IV. The Inflorescence 135
      V. The Fruit 147

Chap. IV. Reproductive Appendages

    Sect. I. Appendages of the Flower 173
      II. Appendages of the Fruit 185

Page
Part II. Imperfect Plants 194
Chap. I. Ferns 195
Sect. I. Conservative Organs 196
II. Reproductive Organs 200
Chap. II. Mosses 206
Sect. I. Conservative Organs 208
II. Reproductive Organs 214
Chap. III. Hepaticæ 226
Sect. I. Conservative Organs 227
II. Reproductive Organs 228
Chap. IV. Algæ 232
Sect. I. Conservative Organs 232
II. Reproductive Organs 235
III. Uses 237
Chap. V. Fungi 239
Sect. I. Conservative Organs 240
II. Reproductive Organs 243

BOOK II.

Of the Internal Structure of Vegetables, or the Anatomy of the Plant 249
Chap. I. Decomposite Organs 250
Sect. I. The Seed 250
II. The Pericarp 268
III. The Flower-stalk, and Flower .. 270
IV. The Leaf-stalk and Leaf 272
V. Gems 276
VI. The Caudex 284
VII. Appendages 299
Chap. II. Composite Organs 301
Sect. I. The Epidermis 302
II. The Pulp 314
III. The Pith 322
IV. The Cortical Layers 325
V. The Ligneous Layers 328
Chap. III. Elementary or Vascular Organs 341

Page
Sect. I. Utricles........................ 348
II. Tubes........................ 350
III. Apertures 364
IV. Appendages.................... 371

BOOK III.

Of the Primary Principles of Vegetables................ 375
Part I. Methods of Vegetable Analysis................. 377
Chap. I. Mechanical Processes................ 378
Chap. II. Chemical Processes.................. 380
Part II. Products of Vegetable Analysis................ 383
Chap. I. Compound Products.................. 383
Sect. I. Gum........................ 385
II. Sugar........................ 388
III. Starch........................ 392
IV. Gluten........................ 396
V. Albumen........................ 397
VI. Fibrina........................ 399
VII. Extract........................ 400
VIII. Colouring Matter............ 403
IX. Tannin........................ 409
X. Bitter Principle............. 412
XI. Narcotic Principle........... 414
XII. Acids........................ 415
XIII. Oils........................ 421
XIV. Wax........................ 427
XV. Resins........................ 432
XVI. Gum-Resins................ 439
XVII. Balsams.................... 443
XVIII. Camphor.................... 446
XIX. Caoutchouc................ 448
XX. Cork........................ 451
XXI. Woody Fibre................ 453
XXII. Charcoal.................... 454
XXIII. The Sap.................... 457
XXIV. The Proper Juice........... 460

Page
XXV. Ashes 464
XXVI. Alkalies 466
XXVII. Earths 469
XXVIII. Metallic Oxides 473
XXIX. General Remarks 474
Chap. II. Simple Products 476

DESCRIPTION OF PLATES.

PLATE I.

FIGURE 1. A spindle-shaped root, The Carrot. FIG. 2. The Bitten root, *Scabiosa succisa.* FIG. 3. The fibrous root, *Agrostis arvensis.* FIG. 4. A bulbous root, the Onion. FIG. 5. The tuberous root, *Ophrys spiralis.* FIG. 6. A zig-zag stem, *Celastrus buxifolius.* FIG. 7. The nodding stem, *Carduus nutans.* FIG. 8. A winged stem, *Lathyrus pratensis.* FIG. 9. A stem twining to the right, *Tamus communis.* FIG. 10. A stem twining to the left, *Convolvulus sepium.* FIG. 11. The culm, or straw, *Bromus pratensis.* FIG. 12. The stipe, *Chamærops humilis.* FIG. 13. Branches in whirls, *Pinus sylvestris.* FIG. 14. Branches decussated, *Dipsacus fullonum.*

PLATE II.

FIGURE 1. A sitting leaf, *Veronica Chamædrys.* FIG. 2. A petiolate leaf, The Vine. FIG. 3. A target-shaped leaf, *Nasturtium* or Indian Cress. FIG. 4. A digitate leaf, The Strawberry. FIG. 5. A winged leaf, *Vicia sativa.* FIG. 6. A leaf trebly winged, Fool's Parsley. FIG. 7. A torn or jagged leaf, *Senecio squalidus.* FIG. 8. A bitten leaf, The Tulip-tree. FIG. 9. Shape of the leaf anomalous, *Nepenthes distillatoria.* FIG. 10. Anomalous, *Sarracenia purpurea.* FIG. 11. Anomalous, *Dionœa Muscipula.* FIG. 12. A ribbed leaf, *Alisma Plantago.* FIG. 13. A plaited leaf, *Alchemilla vulgaris.* FIG. 14. Leaves in whirls, Ladies' Bed-straw. FIG. 15. Leaves turned to one side, *Convallaria majalis.*

PLATE III.

FIGURE 1. The solid bulb, *Crocus sativus.* FIG. 2. Its section. FIG. 3. The scaly bulb, *Lilium candidum.* FIG. 4. The caulinary bulb, *Dentaria bulbifera.* FIG. 5. *Allium*

carinatum. FIG. 6. Glands pedicled, *Rosa tomentosa.* FIG. 7. Glands cup-shaped, Passion flower. FIG. 8. Tendril simple, *Lathyrus Aphaca.* FIG. 9. Stipulæ, a thin scale, *Poa trivialis.* FIG. 10. Stipulæ scariose, *Pinus sylvestris.* FIG. 11. Stings, *Urticus dioica.* FIG. 12. Prickles reflected, *Rosa rubiginosa.* FIG. 13. Prickles forked, *Arduina bispinosa.* FIG. 14. Hairs, *Hieracium Pilosella.* FIG. 15. Root furnished with bags, *Utricularia vulgaris.*

PLATE IV.

FIGURE 1. Proper calyx, *Primula vulgaris.* FIG. 2. Common calyx, *Tragopogon pratensis.* FIG. 3. Glume one valved, *Lolium temulentum.* FIG. 4. Glume two valved, *Avena fatua.* FIG. 5. The scale ovate, *Salix herbacea.* FIG. 6. The scale cleft, *Betula nana.* FIG. 7. Corolla monopetalous, *Campanula rotundifolia.* FIG. 8. Corolla polypetalous, *Galanthus nivalis.* FIG. 9. Cruciform flower, *Cheiranthus.* FIG. 10. Papilionaceous flower, The Pea. FIG. 11. The stamens, *a*; and pistil, *b*; *Lilium candidum.* FIG. 12. The common receptacle, *Leontodon Taraxacum.*

PLATE V.

FIGURE 1. A head of flowers, *Statice Armeria.* FIG. 2. A whirl, *Mentha arvensis.* FIG. 3. A spike, *Veronica spicata.* FIG. 4. A panicle, *Poa nemoralis.* FIG. 5. The Thyrse, *Ligustrum vulgare.* FIG. 6. The Cluster Ribes, *Rubrum.* FIG. 7. The Corymb, *Arabis Turrita.* FIG. 8. The Fascicle, *Dianthus Armeria.* FIG. 9. The Umbel, *Æthusa Cynapium.* FIG. 10. The Cyme, *Sedum anglicum.* FIG. 11. The catkin, *Corylus Avellana.* FIG. 12. The Spadix, *Arum maculatum.*

PLATE VI.

FIGURE 1. Capsule without valves, *Fraxinus excelsior.* FIG. 2. The Pome, *Pyrus Malus.* FIG. 3. The Berry, *Fragraria vesca.* FIG. 4. The Nut-shell, *Corylus Avellana.* FIG. 5. The Drupe, *Prunus Cerasus.* FIG. 6. The Silique, *Cardamine pratensis.* FIG. 7. The Legume, *Pisum sativum.* FIG. 8. The Strobile, *Pinus sylvestris.* FIG. 9. The Scar, *Vicia Faba.* FIG. 10. A Bracte, *Tilia europæa*; *a*, the

bracte; *b*, the flowers. Fig. 11. Nectaries, *Helleborus viridis.* Fig. 12. The tail, *Clematis Vitalba.*

PLATE VII.

Figure 1. Fructification radical, *Pilularia*; *a*, the leaves; *b*, the fruit. Fig. 2. Lycopodium, *Selaginoides*; *a*, the natural shoot; *b*, the leaf and fruit magnified. Fig. 3. Fructification in spikes, *Osmunda Lunaria.* Fig. 4. Fructification dorsal, *Scolopendrium vulgare*; *a*, the natural size; *b*, a capsule magnified. Fig. 5. A stemless Moss, *Orthotricum Brownianum.* Fig. 6. The stem erect, *Bryum ligulatum.* Fig. 7. A reticulated leaf magnified, *Splachnum reticulatum.* Fig. 8. Star or disk; the barren flower of Mosses magnified, *Polytrichum commune.* Fig. 9. Fertile flowers of Mosses, *Funaria hygrometrica.* Fig. 10. Magnified and longitudinal section of a capsule, showing the column in the centre. Fig. 11. Herbage and flowers of the Hepaticæ, *Jungermannia complanata*; *a*, the natural size; *b*, a part magnified; *c*, the sack; *d*, the ovary; *e*, valves of the ovary. Fig. 12. Fructification of the Algæ, *Lichen physodes*; *a*, barren flowers; *b*, fertile flowers. Fig. 13. A stipitate Fungus, *Agaricus campestris*; *a*, the pileus; *b*, the gills; *c*, the veil; *d*, the stipe.

PLATE VIII.

Figure 1. A grain of Wheat, showing the albumen and vitellus; *a*, the seed of its natural size; *b*, the scale-like vetellus; *c*, a section of the albumen. Fig. 2. The embryo and cotyledons, *Vicia Faba*; *a*, the embryo; *b*, the cotyledons. Fig. 3. Net-work of the leaves, *Pyrus domestica.* Fig. 4. Involute leaf, *Pyrus malus.* Fig. 5. Revolute leaf, *Primula vulgaris.* Fig. 6. Obvolute leaf, Sage. Fig. 7. Convolute leaf, *Arum.* Fig. 8. Conduplicate leaf, The Cherry-tree. Fig. 9. The Equitant leaf, *Iris.* Fig. 10. The plaited leaf, Ladies' Mantle. Fig. 11. The circinal, *Pteris aquilina.* Fig. 12. Homogeneous caudex, *Clavaria ophioglossoides*; *a*, its natural appearance; *b*, a longitudinal section. Fig. 13. The tubular stem, Hemlock. Fig. 14. The caudex consisting of bark, wood, and pith, *Quercus*; showing also the concentric and divergent layers. Fig. 15. A portion of the epidermis magnified, *Saxifraga umbrosa.*

Fig. 16. Bundles of simple tubes, Leaf-stalk of the Primrose. Fig. 17. Spiral tubes, Leaf-stalk of the Artichoke.

PLATE IX.

Figure 1. Evolution of the radicle, The Onion. Fig. 2. Evolution of the cotyledons, *Phaseolus communis*; *a*, the cotyledons. Fig. 3. Evolution of the plumelet, *Fagus sylvatica*; *a*, the plumelet. Fig. 4. Evolution of the stem, *Prunus Padus*. Fig. 5. The Fox-tail root, *Salix communis*. Fig. 6. The flattened stem, *Fraxinus excelsior*. Fig. 7. Plexus of shoots, The Sloe-thorn. Fig. 8. The Oak-apple, *Quercus robur*. Fig. 9. Bunch on the stem of the Dog Rose. Fig. 10. Multiplicate flower, described at page 288. *Primula veris*. Fig. 11. A Proliferous flower, The Daisy. Fig. 12. The foliated fruit, *Pyrus*.

ERRATA.

Page 78, line 13, *for* Riamnus *read* Rhamnus.
—— 127, — 14, *for* triquetur *read* triqueter.
—— 137, — 12, *for* Marubium *read* Marrubium.
—— 149, — 23, *for* Leontarus *read* Lontarus.
—— 150, — 2, *for* Staphyllea *read* Staphylea.
—— 150, — 28, *for* Onobrychus *read* Onobrychis.
—— 169, — 15, *for* Vinea *read* Vinca.
—— 260, — 7, *for* Bideus *read* Bidens.

THE BINDER

Will place Plate I. as Frontispiece to Vol. I. and Plate IX. as Frontispiece to Vol. II. All the other Plates, viz. II. to VIII. inclusive are to come at the end of Vol. I.

HALLIDIE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

A SYSTEM

OF

PHYSIOLOGICAL BOTANY.

INTRODUCTION.

THE great profusion of vegetables which cover the surface of the earth and adorn it with their bloom or verdure, as well as the great and indispensable utility of vegetable productions to the support of animal life, must necessarily have attracted the notice and excited the inquiries of mankind even in the earliest ages. Hence the study of plants may be regarded as co-eval with the creation of man. But to this study, it is to be believed, that men were originally stimulated only from the impulse of their immediate wants; regarding—not the invention of methods nor discovery of scientific truths, but the means of converting the productions of nature to their use and accommodation. It is long before the mind is allured to the study of the works of God merely from the love of speculative knowledge. And in the progress of the study of plants, there were many stages preparatory to this period of advancement.

The first and incipient stage was that in which the attention of the human mind was directed to the discrimination of vegetables, as furnishing by spontaneous production the indispensable necessaries of life. This was the period of the origin of mankind, when man was yet obedient to his God, and God satisfied with the work of his hands, the spontaneous productions of the vegetable kingdom having been given unto man for food.* In the fabulous history of heathen mythology, it was represented by the poets as the happy period of the golden age, when laws were yet unnecessary, and arts and sciences unknown, and men simple in their manners, and temperate in their desires, contented with the frugal repast that was furnished by the hand of nature.†

A. C. 4004.

Its progress as deducible from scripture.

A second stage was that in which men began to direct their attention to vegetables, as capable of furnishing, by means of cultivation, an increased supply of food, proportioned to the wants of an increased population. Then it was that the labours of agriculture were first rendered necessary, and seeds first sown by the hand of man, doomed for the future "to eat his bread in the sweat of his brow."[*] A. C. 3900, perhaps. This was the period in which we find Cain represented by the sacred historian as "a tiller of the ground,"[†] and the state of society in which the inventors of useful arts were regarded by the heathens as celestial beings that had deigned to reside on earth.[‡]

---

* Gen. i. 29.

† Contentique cibis, nullo cogente, creatis
Arbuteos fœtus, montanaque fraga legebant,
Cornaque, et in duris hærentia mora rubetis,
Et quæ deciderant patula Jovis arbore glandes.
Ovid. Met. lib. i.

A third stage was that in which plants began to be regarded as furnishing not merely necessaries, but comforts—being the period in which we find A. C. 2348. Noah represented as a husbandman, having planted a vineyard and drank of the wine;[||] and corresponding, perhaps, to the period of the invention of wine by the Bacchus of the heathens, or to a similar state of advancement in the domestic arts.

A fourth stage was that in which plants began at length to be regarded and studied, or cultivated as furnishing not merely comforts, but luxuries—the period in which we find the Ishmaelites represented as trafficking in spicery, and balm, and myrrh, which they carried down from Gilead to Egypt in the days of Joseph.[§]

Hitherto there is no vestige to be found of any thing like phytological investigation, though it cannot be doubted that some considerable progress had been already made in botanical remark, from the necessity of discriminating by some striking and peculiar character such plants as were possessed of properties convertible to the use of man.

---

[*] Gen. iii. 19.
[†] Ibid. iv. 2.
[‡] Prima Ceres unco glebam dimovit aratro.
Ovid. Met. lib. v. 341.
[||] Gen. ix. 20.
[§] Gen. xxxvii. 25.

From the fabulous history of the Greeks.

The silence of sacred history, and total want of all other authentic history, leaves us wholly in the dark with regard to the probable progress of the study of plants from the period last mentioned till that of the exode from Egypt, as well as during a long period of years immediately succeeding; and we are indebted to the earlier histories of the Greeks for the next rays of information on the subject, which though faint and evanescent in their character, present to us the study of plants, at least under a new aspect, approaching nearer to our notions of botanical investigation than any thing that has hitherto occurred. Such are the indications exhibited in the account of the famous expedition of the Argonauts and celebrated story of Jason and Medea, who is represented by the poets as being so deeply skilled in the magic powers and properties of herbs as to enable Jason, by means of her instructions in the use of them, to perform the otherwise impracticable conditions of obtaining the golden fleece.* But in pursuit of fiction it is very well known that men have often stumbled upon fact; and it is to be presumed they had already

A.C. 1263.

---

* Creditus accepit cantatas protinus herbas,
Edidicitque usum. *Ovid. Met. lib.* vii. 98.

done so in the case of the study of plants, if we may be allowed to draw any inference from the contemporary story of the renowned Centaurs, whose great chief Chiron is represented as being famous not only for his manly accomplishments and moral virtues, but also for his skill in the medicinal properties of plants; in honour of whom it is supposed that the genus Chironia was originally named.

The celebrated Æsculapius, also the pupil of Chiron, and god and father of medicine, according to the mythology of the Greeks, is said to have been so deeply skilled in the medical virtues of herbs, as to be able by means of them to restore the dead to life.[*] From which miraculous talent, though altogether fabulous, we may however infer the progress of botanical inquiry, at least with a view to the ascertaining of the medical virtues of herbs; in the knowledge of which the Greeks seem now to have made some considerable advancement, as appears from the medical celebrity of Machaon and Podalirius, the sons of Æsculapius;[†] renowned for their skill in the art of healing by means of the application of herbs[‡] at the period of the Trojan

From the Poems of Homer.

---

[*] Namque ferunt famâ Hyppolitum———
———————ad sidera rursus
Ætheria et superas cœli venisse sub auras,
Pæoniis revocatum herbis, et amore Dianæ.
Virg. Æn. vii. 770.

[†] ———————Ασκληπιȣ̃ δυο παῖδε
Ἰητῆρ᾽ ἀγαθὼ Ποδαλείριος ἠδὲ Μαχάων. *Iliad.* B. 731

[‡] Ibid. Δ. 218.

war—an art of such superlative importance that the acquisition of it was deemed an object worthy of the greatest heroes. And hence we find that the medical virtues of herbs had formed part of the study even of Achilles himself.*

A. C. 1183. At this memorable period we have also farther evidence of the progress of botanical knowledge beyond any thing hitherto adduced. For it appears that plants were now studied or cultivated not merely as furnishing the necessaries, comforts, and luxuries of the table, or as useful in medicine and the arts, but also under an aspect altogether unprecedented; namely, as being ornamental in gardening—if I am not inferring rather too much from Homer's description of the garden of Alcinoüs, which at the period of the return of Ulysses, seems to have exhibited a specimen not only of the useful but also of the ornamental;† though no traces of ornamental gardening are to be met with in the history of earlier times, unless we suppose with Pliny, that the hanging gardens of Babylon were built by queen Semiramis. In the Odyssey we have also the first account of the celebrated lotus of the ancients;‡ and of the nepenthes famous for its property of dispelling care.|| Still we have no direct evidence of the institution of any philosophical inquiry

---

* Stat. Achill. ii. 444.

† Ἔνθα δε κοσμηταῖ πρασιαὶ παρὰ νείατον ὄρχον
Παντοῖαι πεφύασιν ἐπηετανὸν γανέωσι. *Odyss.* H. 127.

‡ Odyss. I. 94.

|| Ibid. Δ. 220.

into the subjects of the vegetable kingdom, or phenomena of vegetable life. For although the Greeks had already exhibited the strongest indications of that bold and daring spirit which exalted them ultimately to such eminence in the ranks of fame, and instigated them to the subjugation of the world; as well as of that noble talent for intellectual research which they afterwards so signally displayed, they had not yet found, amidst the din and bustle of arms, the leisure necessary to scientific pursuits.

But the sacred writings furnish us at least with a species of presumptive evidence, implying that something of the kind had been instituted in the days of Solomon, who wrote as it appears a treatise on vegetables; of the character and object of which, whether botanical or phytological, we can however form only conjecture, as the work, whatever it might have been, is now irrecoverably lost, although the short account of it that still remains seems to represent it as a sort of natural history of all plants then known.* A. C. 1004.

But perhaps we should regard the dawn of phytological inquiry as originating in the speculations of Thales, the most ancient of the Greek philosophers, and the first that travelled from Greece into Egypt Presumable origin of phytology. A. C. 604. Thales.

---

* And he spake of trees, from the cedar-tree that is in Lebanon, even unto the hyssop that springeth out of the wall.

1 *Kings*, iv. 33.

for the purpose of being initiated into the mysteries of the knowledge of the Egyptians—For as he devoted himself on his return exclusively to the study of nature, it is likely that the subjects of the vegetable kingdom formed part of the object of his researches. But it is certain they formed part of the object of the researches of his immediate successors; and of the earlier leaders both of the Ionian and Italian schools, with whose discussions we find already mingled some of the nicest and most subtle topics of phytological investigation. Their opinions are however of no value as tending to the advancement of science. They could not have been founded on accurate observation, and certainly not on the basis of any thing like philosophical experiment. But they are important as exhibiting a new and peculiar feature in the study of plants, and the first legitimate evidence of the origin of phytological inquiry. A. C. 550. Of the philosophers of this period who seem to have directed their attention partially, at least, to the study of vegetables, I shall specify only Pythagoras,* the celebrated sage of Samos,

---

* Pythagoras, who is believed to have prohibited his disciples from the use of beans on account of a supposed identity of origin between beans and human flesh, (Hor. Sat. vi. lib. ii.) is said also to have written a Treatise on Onions; (Amat. Lusit. Com. in Diosc. lib. ii. 412.) which, if true, gives him consequently a claim to the merits of having been the first botanical monographist.

Anaxagoras* of Clazomene, Empedocles† of Agrigentum, and Democritus‡ of Abdera; who have not indeed left behind them any writings on the subject; but whose opinions and doctrines are recorded by succeeding philosophers.

Hippocrates. A. C. 400.

To the above primitive and patriarchal names, distinguishable for the institution of a species of phytological investigation, calculated to excite farther inquiry, the next that succeeds in order of time, at least as extending the limits of botanical research, is that of Hippocrates, illustrious for the introduction of a new and enlightened method in the study of medicine, founded upon principles deduced from experience, and theory perfected by practice, by

---

[*] Anaxagoras maintained that the seeds of all vegetables are lodged in the atmophere from whence they descend, along with the rain and dews, into the earth, where they mingle with the soil, and spring up into plants. (Theoph. Περὶ φυτων Ἱστοριας, lib. iii.)

[†] Empedocles appears to have advanced some heterodox opinions on the subject of germination, maintaining that the different parts of the plant are not generated at the same time, but in succession—first the root, and then the stem and branches, according to the season proper to each. (Περὶ Φυτων Ἱστοριας, lib. iii.) He is said also to have attributed sexes to plants, and to have maintained, along with Anaxagoras, that plants are endowed not only with life and sensation, but also with desires and passions similar to those of animals. (Arist. Περὶ Φυτων, lib. i.)

[‡] Democritus seems to have instituted an inquiry into the cause of vegetable tastes and odours, which he attributes to the form of the primitive particles of which plants respectively consist. (Περὶ Φυτῶν Αἰτιων, lib. iv.)

which the art of physic was first exalted to the dignity of a science, and legitimately connected with the study of plants; of which upwards of two hundred species are mentioned in his works. Under the auspices of so great and dignified an example, the study of botany could not fail to be advanced, at least as connected with medicine, if not even as connected merely with a liberal education. Cratejas. Accordingly we find that Cratejas, the contemporary of Hippocrates, wrote a book expressly on the subject of botany entitled ʽΡὶξοτομὶκον, which is now, indeed, entirely lost, if we except not some small fragments said to be still preserved in the imperial library at Vienna.* And it is certain that the study of plants was regarded as an honourable pursuit in the time of Xenophon, who represents it in his Cyropædia as constituting one of the branches of the education of the Persian youth.

Aristotle. A. C. 350. But the first of the Greek philosophers that seems to have instituted an inquiry into the economy of vegetation upon principles any thing like scientific, was Aristotle, the venerable father of natural history and prince of ancient metaphysicians; who wrote two books expressly on the subject of plants, as is presumable from his own promise,† as well as evident from the quotations or references of Averoës and Laërtius; but which are now, it appears, irre-

---

* Willden. Prin. Bot. 413, Eng. Trans.

† Περὶ Γενεσιος Ζωων. το. Α.

Vide

trievably lost. For the two books upon plants, which are found in the present editions of his works, are generally allowed by the best judges to be altogether spurious, and regarded as being a forgery of some learned Arab of the middle ages, afterwards translated into Greek.

Theophrastus. A. C. 300.

His botanical arrangements.

The loss that was thus sustained is in a great measure compensated by the works of Theophrastus the disciple and successor of Aristotle, and prince of ancient botanists; who imbibing or inheriting from his master an ardent desire of prosecuting the study of the works of nature, applied himself to the investigation of the vegetable kingdom with a zeal and industry worthy of the pursuit, and produced as the result of his labours the two works on plants for which he stands so deservedly celebrated—the one entitled Περὶ Φυτῶν Ἱστόριας, the other Περὶ Φυτῶν Αἰτιων. In the former work he describes and arranges plants according to such characters and distinctions as had then engaged the attention of botanists; and in the latter he professes to account for the phenomena of vegetation; though, in truth, the topics of examination are introduced without any thing of systematic method, or at least without any method calculated to throw light on the subject. The specific descriptions, which amount to about five hundred, if compared with modern descriptions, are vague and incorrect; and few of the phenomena of vegetation are satisfactorily explained. But with all their defects still they are works of inestimable value, as containing a great variety of important facts and observations relative to plants, and exhibiting a summary view of the whole mass of botanical and phytological knowledge as it stood at the time; and even setting before us an example of phytological experiment that was not to have been looked for at that early period.

Decline of phytology in Greece.

But unhappily the example of Theophrastus had not the effect of alluring to the study of plants his successors in the peripatetic school, nor of diffusing the love of phytological inquiry among the other schools of Greece. If any thing was written on the subject it is now totally lost; and we can judge of the progress of botany only by inference, from which it appears not indeed to have been wholly neglected, but rather to have made some advancement, countenanced as it then was by the patronage of the great; if the etymology of some names does not mislead us. The plants Lysimachia and Eupatorium are said to have obtained their names respectively from Lysimachus a king of Sicily, and the brave but unfortunate Mithridates, king of Pontus, who are both represented as having been encouragers of botanical investigation.

A. C. 100.

And of botany, with its introduction into Italy.

Still it is evident that the study of plants began to decline among the Greeks along with the decline of empire, and to emigrate with the other arts and sciences into Italy;* where it appears to have been at least well received, though not very cordially cherished. The first vestiges of its existence among the Romans are discoverable in the improved state of agriculture and taste for gardening and ornamental plantations described or alluded to in the works of the Latin classics, from which a good deal of information may be obtained, not only with regard to the then existing state of the knowledge and cultivation of plants in Italy, but also in the countries over which the Roman arms prevailed; as may be seen by consulting the Cato Major of Cicero and the Georgics of Virgil, in which the information is direct; or even the Commentaries of Cæsar, and Annals or other works of Tacitus, in which the information is incidental.

---

* Græcia capta ferum victorem cepit, et artes
Intulit agresti Latio. *Hor. Epist.* i. *lib.* ii.

It does not however amount to a proof that the study of plants was pursued with any great degree of avidity among the Romans, as the Romans like the early Greeks were yet too much engaged in the tumult of war to have acquired any considerable relish for the study of natural history. And hence the first direct evidence of the existence of any inquiry that can be called strictly botanical among the Romans is that which is furnished in the works of Dioscorides and Pliny, names well known in the annals of botany, and illustrious in having been long regarded by the learned as the best and most infallible guides to the study of plants.

And progress under

But great although their reputation deservedly was, botany derived from their labours but little ad-

Dioscorides and Pliny.

vantage; the work of the latter on that subject being rather detatched histories of some of the most curious and singular plants then known, intermixed with a great deal of loose and vague report, than any thing like scientific inquiry;—in which, however, we have the only remaining traces of the botanical knowledge of the Druids, the ancient priests and rulers of Gaul and Britain, who were acquainted with the medical virtues of a variety of plants, but particularly of the missletoe of the oak, which they revered as sacred;—and the work of the former being rather a body of materia medica than of botany, so that the sarcasm of Rousseau in which he has complimented the author with the title of "a great compiler of receipts," has perhaps as much of truth in it as of wit.

Its fate during the dark ages.

But their example, which was indeed truly laudable, seems to have been as much neglected among the Romans as that of Theophrastus was among the Greeks; and as the study of botany originated, so it perished with them in Italy, and lay like all other departments of science buried in the ignorance or barbarism of the dark ages, except in as far as it might be cultivated by a few Asiatic Greeks or Arabians, among whom the names of Galen and Avicenna stand pre-eminent, till the period of the revival of learning in Europe.

And revival with the revival of letters.

At this memorable epocha, which we may fix at about the beginning of the fifteenth century, the study of plants began again to engage the attention of the learned, and to be pursued with a degree of industry unknown before; while the writings of Dioscorides and Pliny, which with all their defects or redundancies were still regarded as the grand standard of botanical knowledge, began to be studied and commented upon with the most indefatigable zeal.

Introduction of figures from wooden cuts.

One of the first fruits of this revived passion for botanical inquiry was the introduction of the aid of figures, with a view to elucidate verbal description which had not yet attained the degree of accuracy that is necessary to determine the species. The merit of this great and important improvement is due to Brunfelsius, a native of Maynz in Germany, and first German botanist. His work, entitled Historia Plantarum, was published about the beginning of the sixteenth century, and the figures, though only from wooden cuts, have been regarded by good judges as exhibiting, in general, a tolerably good representation of the intended plants. They served at least to excite the emulation of other botanists, and were accordingly soon after followed by those of Bock, Cordus,Fuschius, Dodonæus, and Clusius, all natives of Germany; who each added something to the number or accuracy of the figures of his predecessors in publication.

But the flame that was thus kindled up in Germany soon began to extend itself to surrounding nations, and to excite in the adjacent countries a similar ardour for botanical inquiry. In Italy the celebrated Mathiolus was the first to catch its incipient emanations—in France Delachamp and the elder of the Bauhins, embracing in one comprehensive view the whole of the vegetable kingdom—and in our own country Turner and Gerarde, whose herbals are monuments, at least, of their great and indefatigable industry and love of botanical research.

Such were the happy effects resulting to the study of botany, from the new impulse communicated to the energies of the human mind in the revival of letters.

Of methodical arrangement.

But in the works of all botanists there was still one capital defect, that rendered the study of plants extremely perplexed and uninviting. Their figures and descriptions were wholly without method; so that the mind was yet occupied merely about individuals without having attended sufficiently to those features of vegetable character by which its ideas might have been generalized, and its labours abridged. The inconvenience resulting from this defect began now, however, to be severely felt, and the necessity of method to be plainly perceived. It was an object worthy of the labours of the learned to ascertain and establish the principles of scientific arrangement, and accordingly the first hints on the subject were suggested by Conrad Gesner, a native of Zurich in Switzerland, and the greatest naturalist that had appeared since the time of Aristotle; who borrowing the idea perhaps from Aristotle's zoological arrangements, suggested the method of arranging plants into classes, orders, and genera, accord-

By Gesner.

ing as they agreed or differed in the figure and structure of their several parts, regarding the parts of the flower as being the best fitted for the purpose. This notable improvement was suggested by Gesner about the middle of the sixteenth century, forming, as we cannot but regard it, a new era in the history of botany.

But while Gesner was employed in Germany in maturing his plans of method, the same necessity of methodical arrangement was also felt and pointed out by an eminent botanist of Italy, though without any communication, as it seems, with Gesner.* This was the celebrated Cæsalpinus, a native of Arezzo in Florence, and physician to Pope Clement the eighth; who, with a mind formed for accurate investigation, and much practised in the metaphysics of the times, and imbued with the principles of sound philosophy, applied himself to the study of botanical arrangement, not only with the best qualifications but with the happiest issue. For what Gesner contemplated only in theory, Cæsalpinus reduced to practice, presenting to the world the first specimen of a methodical arrangement of plants; and reflecting, at the same time, a greater degree of light upon the structure and affinity of vegetables than any preceding botanist. His method, which is exceedingly simple, is founded chiefly upon the fruit.

By Cæsalpinus.

The above are not the only proofs of the ardour with which botanical investigations were prosecuted

---

* Smith's Introduction, p. 351.

Institution of botanical travels.

at this period. The rapid progress of the study displays itself also in the travels and voyages that were undertaken for the purpose of new discovery; of which I shall specify only the examples of Camerarius of Nuernberg, Jungermannius his nephew, Prosper Alpinus, Rauwolfius, and the two Acostas, who travelled respectively over Italy, Greece, Egypt, the shores of the Levant, and lastly undertook voyages even to India in quest of plants. And hence also the origin of herbariums of dried plants for the purpose of preserving the specimens collected; which with the additional improvement of copper-plate figures that were now for the first time introduced into botany by Columna of Naples, gave a facility and precision to botanical inquiry unattainable before.

And of herbariums.

Introduction of copper-plate figures.

And botanic gardens.

But the progress of botanical knowledge thus promoted by the labours and investigations of the learned, owed also much of its advancement to the patronage of the rich and the great. This is particularly evidenced in the institution of botanic gardens, whether public or private, which history now introduces for the first time, and which the Italians, eager in the pursuit of new plants, were the first to establish. Of the former sort the most ancient is thought to be that of Padua, instituted in 1533, and soon after followed by those of Florence, Pisa, Bologna, and Leyden; and of the latter sort, perhaps, the most ancient was that of William Landgrave of Hesse, arranged as it is said by Camerarius, and followed by that of Gerard at London, established at the latest in 1596.

Temporary decline of botany.

From this memorable period of improvement, in which the Hurculean labours of the Bauhins, as well as the arrangements of Cæsalpinus had not only advanced the study of vegetables to an unprecedented height, but seemed also to have ensured its continued and unremitted progress; botany, as represented by botanical historians, appears notwithstanding to have languished for a period of nearly half a century; which might perhaps have been owing to the impossibility of outdoing the Bauhins in their own line of investigation, and upon their own principles. But if the progress of the study of vegetables was thus suspended in as much as relates to the collecting, describing, and figuring of plants, there is, at least, one view of the subject in which it was most essentially advanced; and that is in the revival, if I may not absolutely say original introduction, of phytological investigation, which had been but just attempted by Theophrastus, and consigned to the most culpable neglect by succeeding botanists for a period of nearly two thousand years.

Revival of phytological research.

The revival of this study was probably owning to the new impulse and new direction communicated to the spirit of philosophical inquiry by that great and illustrious luminary of science Francis Bacon, Lord Verulam, who having explored and developed the true foundations of human knowledge with a sagacity and penetration unparalled in the history of mankind, and having dared to disengage himself from the fetters of academical authority, denounced, as vain and idle, the visionary speculations of the schools, and boldly pointed out the necessity of a complete and thorough revolution in all preestablished methods of study; recommending the more tedious, but yet more successful method of analytical and inductive investigation,* and proclaiming truth to be but the image of nature.†

But to whatever cause it is to be attributed, the fact is, that two different sets of phytological experiments modelled upon the principles and method pointed out by Bacon, and with a view to elucidate the phenomena of vegetation, were instituted about nearly the same time by two celebrated anatomists and accurate observers of nature, residing in different countries and having no communication with one another. These naturalists were Grew and Malpighi, the latter an Italian, the former an English physician. For as Gesner and Cæsalpinus had been led as it were instinctively to the study of methodical arrangement without any mutual intercourse, so were Grew and Malpighi to the pursuit of phytological inquiry—a circumstance likely to happen at a time when the spirit of true philosophy had begun to diffuse itself among men of speculative habits, of whom many, no doubt, would be led to view the same subject in the same light.

---

* Inductio legitima et vera, ipsa clavis est naturæ interpretationis. *Nov. Org. lib.* ii. *Aph.* x.

† Scientia nihil aliud est quam veritatis imago, nam veritas essendi et veritas cognoscendi idem sunt. *De Aug. Sci. lib.* i.

And mode of investigation adopted.

The result of the investigations of these illustrious phytologists was first communicated to the public towards the end of the seventeenth century; and it must be confessed that the success of their labours made amends, in a great measure, for the long neglect of preceding naturalists. For though they had no tract to direct them in this obscure and intricate investigation, yet by joining patience to penetration, and experience to philosophy, and by adopting the only sure means of detecting the secrets of nature—the experimental mode of inquiry—exploring most scrupulously the internal and recondite structure of the plant, and watching with unwearied application the functions of the different organs, they succeeded in removing much of that veil which had enveloped the phenomena of vegetation; and in opening up to the observation of man a new view of the works of God.

Concomitant advancement of botany.

But the principles of the philosophy of Bacon, which were thus so succesfully applied to phytology, were extended also to botany—particularly on the subject of arrangement and ground of generic distinction—the necessity of which was now more than ever indispensible for the purpose of reducing to order the immense mass of particular specimens collected and described by the increasing multitude of adventurers in the field of botanical discovery. Accordingly, in pursuit of this important object, the talents and industry of the learned were now also more than ever exerted, and a variety of systems introduced, adopted, and abandoned in their turns.

In the introduction of unproved methods.

Of these the principal were the methods of Morrison, Ray, Tournefort, Rivinus, Boerhaave, Herman, and Magnol, which appeared about the end of the seventeenth or beginning of the eighteenth century, and which, whatever might have been their defects, had at least the merit of exhibiting botany under a new and systematic form. But the most celebrated as well as the most beautiful of them all was that of Tournefort, which was adopted in France with a kind of epidemic enthusiasm characteristic of the nation, and admired by botanists of all countries. It had indeed much merit, at least as exhibiting the first model of generic discrimination, founded on principles truly philosophical. But it had also its defects; for though extremely beautiful in speculation, it was yet clogged with insurmountable difficulties in the practice.

And principles of generic discrimination.

No method of arrangement, therefore, had yet been discovered sufficiently suited to the exigency of the case; and a method founded on principles more easily reduced to practice was still the grand desideratum of botany.

Which are perfected by Linnæus.

In this peculiar crisis of botanical perplexity, when specimens were every day multiplying in the hands of collectors, and herbariums devoid of arrangement, and the science in danger of relapsing again into an absolute chaos; a great and elevated genius arose destined to restore order,—who, surveying the immense mass of materials with a sagacity and penetration unparalleled in botanical research, and seizing, as if by intuition, the grand traits of character calculated to form the ground-work of a philosophical division, detected the clue by which he was to extricate himself from the intricacies of the labyrinth, and rear the superstructure of a legitimate method; so that the touch of his skilful hand was no sooner applied to the work, than the trees, as if moved by the music of Orpheus, arranged themselves around him. This great and illustrious naturalist was the celebrated Linnæus, founder of the sexual system, and prince of all botanists, who deducing his rules of method from the most incontrovertible of all principles, and establishing the laws of generic and specific distinction, and even rules of legitimate definition,* introduced into the study of botany a simplicity of system, a perspicuity of arrangement, and a precision of language, which have elevated it to the high rank it now holds in the scale of human knowledge, as well as allured to the study of the science men of the most distinguised abilities, and excited that ardour for botanical investigation which characterizes the present age. Of the immediate disciples of Linnæus, the most distinguised were Kalm, Hasselquist, Lœfling, and Kœnig, all of whom travelled in pursuit of new plants under the auspices of their great master. And of his succeeding followers or more remote disciples, the most distinguished are Gmelin, Oeder, Hedwig, Gærtner, Lamark,—and as the last I shall now specify, though not the least in merit of the six, Sir James Edward Smith, the founder and president of the Linnæan Society of London, and proprietor of the whole of the Linnæan Herbarium; from whose unremitted and meritorious labours, botany has derived the most important advantages.

---

* Vide. Lin. Phil. Bot.

Who extends his researches to phytology.

But the labours of Linnæus were not confined merely to the improvement of systematic botany, whether according to natural or artificial principles, and to the fixing of the laws of generic and specific discrimination and definition; but the very foundation of his artificial system, and grand anchor of its stability, involves one of the most important questions in the whole extent of physiological botany—namely, that of the sexes of plants. This doctrine which had been recognized by the ancients, at least as applicable to some plants, extended by Cæsalpinus to all diæcious plants, and suspected by Grew to be true with regard to all plants whatever, had not yet been put to the test of due experiment. Some experiments had indeed been instituted with a view to ascertain the fact; first, by Camerarius, professor at Tubingen, and afterwards by Vaillant, which tended to throw considerable light upon the subject. But the doctrine was still involved in doubt, and the decision of the question was reserved for the great Linnæus, who following the lights of the reformed philosophy, and putting into practice the principles of an improved logic, as examplified in a full and legitimate induction of particulars, solved, at last, the important problem, and proved beyond all controversy the universality of the sexes of plants; confounding the opposers of the doctrine by the irresistible force of his arguments, and founding and supporting his conclusions on a cloud of the most indisputable facts.*

Which he connects with botany.

Thus in the investigation of the vegetable kingdom, a close and intimate union was at last effected between the systematic and physiological departments, of which the propriety and advantage are equally evident; the study of the former being the best avenue to the study of the latter, and the thorough knowledge of the vegetable involving the study of both.

And which is eminently advanced by the ardour of modern inquiry.

But great as the progress of modern systematic botany has undoubtedly been, the progress of modern physiological botany is, perhaps, still greater. For to give an idea of the mass of talent that has been directed to the elucidation of this difficult department of the study of vegetables since the period of the investigations of Grew and Malpighi, it will be sufficent to mention, in addition to the name of Linnæus, that of Hales, Bonnet, Du Hamel, Hedwig, Spallanzani, each of whom has peculiarly distinguished himself in the field of phytological investigation, and eminently contributed to the advancement of the science. But especially the name of the persecuted, though perhaps prejudiced, Priestly, deserves to be particularized, as being the first who introduced into the study of phytology the aid of pneumatic chemistry, which, under the happy auspices of Ingenhouz, Senebier, Saussure, and others, has done more to elucidate the phenomena of vegetation, than all other means of investigation put together; so that our knowledge of the physiology of vegetables may now be regarded as resting upon the foundation of a body of the most incontrovertible facts, and assuming a degree of importance inferior only to that of the physiology of animals.

---

* Spons. Plantarum Amœn. Acad. vol. i.

And application of pneumatic chemistry.

Leaving still the desideratum of a detailed view of the structure of vegetables.

But although the labours of phytologists have been directed with success to the explication of a variety of the most important phenomena of vegetation, and although we have been already favoured with a condensed and systematic view of the result of their investigations by writers of the highest celebrity, yet there seems to be still wanting some work that shall exhibit them more in the detail, and serve the purpose not merely of a brief and rapid sketch to assist the recollection of the adept, but of a clear and copious introduction to facilitate the studies of the novice, by presenting to him—first, such an elementary view of the vegetable kingdom in general as shall be directly preparatory to physiological research; and secondly, such a view of the process of vegetation as shall render the *rationale* of the preceding phenomena preparatory to that of the following, and shall not necessarily suppose any previous knowledge of the subject.

This will involve, in the first place, an inquiry into the structure of vegetables as being organized substances; which naturally divides itself into two distinct departments—the external structure of the plant, and the internal structure or anatomy of the plant; the former including such parts and peculiarities as are discoverable by means of outward inspection, and the latter, such parts or organs as are discoverable only by dissection. Secondly, it will involve the chemical analysis of vegetables and vegetable productions, as being the best means of ascertaining the character of the nourishment on which the plant naturally feeds. Thirdly, it will involve an account of the functions of the several organs of vegetables and phenomena of vegetable life, as being the grand and leading object of all phytological investigation, to which the foregoing inquiries are only preparatory steps. And lastly, it will involve the phenomena consequent even upon vegetable death, as comprehending the process by which the vegetable substance is ultimately reduced to the primary and unorganized principles of which it was originally composed, and rendered capable of mingling again with the soil or atmosphere, or of entering into the composition of new vegetable bodies.

External and internal.

With an analysis of vegetable substances.

And phenomena of vegetable life.

And death.

Such is a brief and rapid sketch of the origin, progress, and present state of the study of plants; together with a condensed view of the object and principal departments of the present work, which it now remains to exhibit in the detail.

BOOK I.

OF THE EXTERNAL STRUCTURE OF VEGETABLES.

In surveying the subjects of the vegetable kingdom as planted by the hand of nature, the spectator readily recognizes certain traits of resemblance or of dissimilitude that occur in the form, structure, or habit of the several individuals of which the whole is composed, indicating the propriety and means of distributing or arranging them into distinct groups or classes; and suggesting the notion of vegetable tribes or families. Perhaps the most ancient division of vegetables that ever was instituted is that by which they are distributed into trees, shrubs, undershrubs, and herbs—a division obviously founded in nature, but not sufficiently general for the purposes of the present work.

But vegetables may be regarded as a natural assemblage of individuals reducible to classes according as they are distinguished by a structure or organization more complicated or more simple; or, according as they are found to be formed with, or without, certain parts or organs entering into the general idea of the plant. The former will constitute what may be denominated Perfect Plants, and will form a class comprehending the principal mass of the vegetable kingdom. The latter will constitute what may be denominated Imperfect Plants, and will form a class comprehending all such vegetables as are not included in the foregoing class. The two classes, therefore, evidently exhaust the subject; and the division, whatever might be its value or want of value, as the ground of a systematic arrangement, will be here adopted.

PART I.

PERFECT PLANTS.

IF a plant of the perfect class is detached from the soil, and surveyed externally in the season of flowering, it may be perceived, even by the most inattentive observer, to be composed of the following distinct parts; the root, the trunk, the branch, the leaf or frond, the flower, the fruit, and perhaps the seed, which, together with their several peculiarities and accompaniments or appendages, are now to be considered. And perhaps no farther classification is absolutely necessary beyond that of taking the several organs in the order in which they have been just named. But as botanists do occasionally distribute them into several distinct divisions, according to the function, duration, or other leading feature of each, it will be proper to take notice of the divisions into which they are thus distributed.

Distribution of their several organs.

A division instituted by Linnæus distributes them into the root, herb, and fructification, the herb comprehending the trunk, branches, and leaves; and the fructification, the flower and fruit.* This is perhaps correct enough considered merely as a division; but

Into root, herb, and fructification.

---

* Phil. Bot. sect. 79.

is objectionable with regard to the use of one of the terms employed. For as the term herb was previously appropriated to the designation of a peculiar class or division of plants, it ought not to have been employed to signify also a part of the plant itself.

Into permanent and temporary organs.

Another division is that by which the parts in question are distributed into permanent and temporary or deciduous; the permanent parts being the root, stem, and branches, which continue to exist as long as the plant vegetates; and the temporary parts being the leaves, flower, and fruit, which fall off and are renewed annually, at least in plants that are themselves perennial.

Into conservative and reproductive organs.

A third division is that by which the parts of the plant are distributed into conservative and reproductive, as corresponding to their respective functions in the economy of vegetation; which principle of division shall be here adopted, and the parts distributed as follows: conservative organs, conservative appendages, reproductive organs, reproductive appendages.

CHAPTER I.

CONSERVATIVE ORGANS.

The conservative organs are such as are absolutely necessary to the growth and preservation of the plant, including the root, trunk, branch, leaf, and frond; of which in their order.

SECTION I.

The Root.

Its definition.

THE root is that part of the plant by which it attaches itself to the soil in which it grows, or to the substance on which it feeds, and is the principal organ of nutrition. This definition is perhaps as comprehensive as any one that can be given, at least in the present stage of our inquiries, whether with regard to the class of perfect or imperfect plants; though it is no doubt liable to many exceptions if made to apply to both. For even of plants denominated perfect some are found to float on the surface of the water, having their roots immersed in it but not fixed,—such as the several species of *Lemna* or Duck-meat; and of plants denominated imperfect some have no root at all; or, at least, no visible part distinct from the rest to which that appellation can be ascribed; such as many of the Confervæ; or they are apparently altogether root, such as the *Tuber cibarium* or Truffle.

There are also many of the imperfect plants which attach themselves to other vegetables, and to vegetable or other substances from which they cannot be supposed to derive any sort of nourishment whatever, owing either to the mode of their attachment or to the character of the substances to which they attach themselves. Such are many of the Mosses, Lichens, and Marine Plants found adhering to the outer and indurated bark of aged trees, to dead or decayed stumps, to rotten pieces of wood, and frequently even to stones.

These therefore are to be regarded as exceptions to the rule, which includes, however, parasitical plants that have generally occasioned some difficulty. For although parasitical plants are not found to attach themselves to the earth or soil, but to some other living vegetable, as in the case of the *Viscum* or Missletoe, which grows upon the Apple-tree or the Oak, yet it is from the plant to which they attach themselves that their nourishment is derived.

But almost all plants of the perfect class are fixed in the earth by a root descending in species of large growth, and sometimes even in species of small growth, to a considerable depth below the surface, and spreading, by means of lateral divisions, to a considerable extent around the centre. The divisions of the root of the Baobab or African Calabash-tree, have been known to measure upwards of one hundred feet in length.

The collar. At the point of union between the root and upper part of the plant, there may generally be perceived a sort of annular bulge or protuberance surrounding or encircling it. It is most discernible in the early stages of the plant's growth, and is then particularly conspicuous in the Horse-chesnut. It is, I believe at present without a name, at least among English botanists. French botanists call it *Le Collet*, the collar.

The root is regarded by Linnæus as consisting of two parts, the *caudex* and *radicula*.* The former constitutes the body of the root, the latter the fibres which issue from its surface.

As roots have been found to exhibit a considerable variety of shape, size, and structure, analogous to the peculiarities affecting the general habit of the plant, they have, accordingly, been found to be of particular utility in the discriminating of species, and have been distributed for the convenience of botanists, and for the sake of giving precision to botanical description, into several different sorts, of which the following are the principal.

SUBSECTION I.

The Spindle-shaped Root.—The spindle-shaped root (*Pl.* I. *Fig.* 1.), which is a root tapering gradually, as its name implies, from the base or collar to the apex, and descending to a considerable depth in the soil, is so very well known in the common and familiar examples of the Carrot and Parsnip, that perhaps no illustration of it is necessary beyond a mere reference to the roots of these plants.

SUBSECTION II.

The Bitten or Truncated Root.—The bitten or truncated root (*Pl.* I. *Fig.* 2.) is a root tapering gradually like the spindle-shaped root, but terminating abruptly as if the lower extremity were cut or bitten off. It is exemplified in the plant called Devil's-bit, or Devil's-bit Scabious—*Scabiosa succisa;* which affords, at the same time, an example of the whimsical and superstitious notions entertained by the simplists of ancient times with regard to the virtues inherent in plants. Almost all plants were supposed to possess some peculiar and medicinal virtues. But here was a plant with part of the root bitten off. The inference accordingly was, that the part wanting must have been bitten off by the Devil out of sheer malice to mankind, and on account of the peculiar potency of its medical virtues.* But unluckily for the patients of modern times, the medicinal virtues of this plant do not, upon inquiry, turn out to be any way remarkable; and the deficiency of the part bitten off has been accounted for in another way.

---

* Phil. Bot. sect. 80.

Its supposed medical virtues.

SUBSECTION III.

The Fibrous or Capillary Root.—The fibrous or capillary root (*Pl.* I. *Fig.* 3.) is a root consisting of several small and thread-like fibres, of which one is generally central, and the rest lateral, supporting the plant not by their individual strength but by their numbers and distribution, elongating in a divergent direction, and rivetting down the plant on all sides. Such are the roots of most of the Grasses, as exemplified in the case of Wheat, Oats, Barley.

---

* Gerard's Herbal, 587.

SUBSECTION IV.

Solid, coated, or scaly.

The Bulbous Root.—The bulbous root (*Pl.* I. *Fig.* 4.) is a root consisting of a circular assemblage of small fibres originating in the under surface of a bulb or knob, solid or composed of succulent coats or scales, and containing the rudiments of a future plant, as exemplified in the bulbs of the Crocus, Tulip, and Lily. Hence bulbs are vulgarly regarded, and very often described, as being altogether roots —perhaps because they are wholly lodged in the soil when planted by the gardener or florist. But the truth is, that the fibres issuing from the under surface of the bulb are the only true and efficient root; because if they are entirely cut away, the bulb will not germinate. And on this account some botanists have objected to the term bulbous root altogether, since the bulb is in fact no part of the root. But there can be no impropriety in retaining the term if we are only careful to annex to it a true and correct idea, remembering that it signifies only a root furnished with a bulb, and not regarding the bulb as a root of itself. Whence it follows, that the bulbous root is only in fact a fibrous root with a bulb attached to it.

SUBSECTION V.

The Tuberous Root.—The tuberous root (*Pl.* I. *Fig.* 5.) is a root consisting of a knob or tubercle furnished with a number of small and scattered fibres; or of a number of knobs or tubercles united by means of such fibres, and forming a cluster. If the knob is single it is generally of a spherical form, as in the Earth-nut, *Bunium Bulbocastanum*, and *Arum maculatum;* though in some cases the knob, when it attains to its full growth, becomes hollow as in that of *Fumaria cava*.

Its varieties.

But of roots consisting of more than one knob there is a considerable variety. Sometimes the knobs are in pairs, as in the root of the *Ophrys spiralis*, or Ladies' Traces, and of the early Purple Orchis. If a pair of these knobs is taken and separated and then immersed in water, the one will be found to sink and the other to swim. This is a phenomenon that seems also to have puzzled the simplists of antiquity not a little; and to have given rise to a great deal of idle and superstitious conjecture. It was thought that the knob that swims must necessarily have possessed some peculiar and potent properties, and accordingly some potent properties were very liberally ascribed to it. If prepared in a particular manner and worn about any one's person, it was believed to have the singular property of exciting, by means of proper management, a violent attachment to the wearer in the breast of any one he pleased. And this belief is still a vulgar error among the ignorant and superstitious; though the sinking of the one knob, and the swimming of the other, have been accounted for from the regular operation of natural causes, and the mystery and magic charm of the phenomenon altogether dissolved.

From the swimming knob which was generated in the course of the preceding year, the plant of the present year, together with the sinking knob, has sprung; but by this means the substance of the swimming knob has become exhausted, and specifically lighter than water, and on this account it swims. The sinking knob, which is still firm and solid, is of course specifically heavier than the water, and on this account it sinks; but in the succeeding year it also will produce a new plant and knob, and will then become the swimming knob itself, and fade and decay in its turn.

Sometimes the knobs are palmate, that is, consisting of several divisions that have in the aggregate a slight resemblance in shape to that of the human hand, an example of which variety may be seen in the root of *Orchis latifolia.*—Sometimes they are arranged in clusters, of which the individuals are cylindrical, as in the root of *Ophrys Nidus avis* or Bird's-nest Ophrys. —Sometimes they are crowded together in clusters of which the individuals are small and globular, as in the root of *Saxifraga granulata* or White Saxifrage;

and sometimes they are dispersed in large and scattered lumps united together by thread-like fibres, as in the root of the Potatoe.

SUBSECTION VI.

Lateral fibres.

General Remarks.—Such are the principal sorts of roots distinguished by botanists, at least as regarding the general outline of their figure. But the small fibres issuing from the surface of the caudex which are essential to complete the notion of a root, must now also be noticed. Sometimes they are scattered as if at random over the whole surface of the caudex or main division, issuing promiscuously from all parts of it, but particularly from the apex, as in the case of *Malva sylvestris* or the Common Mallow. Sometimes they issue from the caudex in whirls situated at regular intervals, at least in plants vegetating in the water or affecting a marshy situation, as in the root of *Hippuris vulgaris*, and *Cicuta virosa*. Sometimes they issue from the upper extremity of the caudex, as in *Scabiosa succisa*; but always from the lower extremity of the true bulb, where, indeed, they are to be regarded as constituting alone the root.

Furnished with secondary fibres.

But the fibres thus issuing from the caudex, to which they are generally lateral, are again furnished with still smaller fibres lateral to themselves, and terminating at last in fine capillary, and often transparent points, which are said to be renewed annually;* being originally protruded in the spring, perishing in the winter, and again succeeded by a new set in the spring following. Hence they seem to bear the same relation to the root that the leaves bear to the stem or branch.

If roots are viewed with regard to their direction as penetrating the soil, some will be found to descend perpendicularly, others obliquely, and others to extend themselves in a direction parallel to the horizon. The direction.

If viewed with regard to their surface they are marked with scars or inequalities; or covered with scales, or beset with a fine down, or with soft and fine hairs.

If viewed with regard to their substance they are milky, as in *Sonchus arvensis,* or Corn Sow-thistle; or fleshy, as in *Tamus communis* or Black Briony; or woody, as in the roots of shrubs and trees. Substance.

The colour of the root is generally darkish; though in some plants it is white, as in Horse-radish; in some yellow, as in Broad-leaved Dock; and in some red, as in the Carrot. Colour.

The odour of the root is often one of its most distinguished properties; being sometimes strong and ungrateful, as in Wild Valerian; sometimes pungent and penetrating, as in Horse-radish; and sometimes spicy and aromatic, as in Spignel and Sweet Cicely. In *Pucedanum officinale,* it resembles that of sulphur. Odour.

---

* Physique des Arbres, liv. i. chap. v.

Taste. The taste of the root is mild and grateful, as in the Carrot and Parsnip; or it is hot and acrid, as in Bulbous Crowfoot; or it is bitter and nauseous, as in White Hellebore; or it is lusciously sweet, as in Liquorice-root.

Size. The size of the root, if compared with that of the plant of which it forms a part, is in some cases very large, as in the Beet-root and Carrot; while in others it is very small, as in common flax.

Duration. The duration of the root is either annual, biennial, or perennial; annual if it subsists but for one year or season, as in the Pea and Bean; biennial if it subsists for two years, as in *Dipsacus Fullonum* or Fuller's Teasel; and perennial if it subsists for many years, as in the roots of trees and shrubs.

And medical virtues of roots. Finally, the dietetical and medical virtues of plants are frequently found to reside in the root. The Carrot, Potatoe, and Parsnip, are well known examples of the former; and the Mezercon and Meadow-saffron are notable examples of the latter.

SECTION II.

The Trunk.

Its definition. The trunk is that part of the plant which, springing immediately from the root, ascends in a vertical position above the surface of the soil, and constitutes the principal bulk of the individual. It has been represented by Linnæus as being the caudex ascendens or root above ground.* But without waiting to offer any illustration of this comparison, which is perhaps more fanciful than philosophical, I shall proceed to consider trunks as distributed into distinct species according to the peculiarities of their form and structure. The species proper to perfect plants are the three following: the stem, the culm, and stipe, of which in their order.

Its species.

SUBSECTION I.

The Stem.—The stem is the trunk of trees, shrubs, under-shrubs, and the greater part of herbs. In most plants it is of a cylindrical form, tapering towards the upper extremity, as in the oak and elm. But in some it is compressed or flattened on both sides, with the edges or angles more or less blunt, as in Flat-stalked Pond-weed; in some it is triangular, as in most species of Carex; in some it is quadrangular, as in Figwort; in some it is fluted or furrowed with longitudinal grooves, as in common Cow-parsnip; in some it is winged,† that is, furnished with a membranaceous and leafy prolongation of the angles, as in Narrow-leaved Lathyrus; and in some it is jointed, that is, having the appearance of a number of pieces joined together, and forming a knot at the point of union, as in the Pink. Such are the most common varieties of figure exhibited in the

Its figure.

---

* Phil. Bot. sect. 80.

† *Pl.* I. *Fig.* 8.

stem, from which, as well as from several others, the species is often very happily characterized.

Structure. If viewed with regard to their structure, stems are either simple, that is without divisions, as the stem of the White Lily, or compound, that is consisting of two or more divisions, as in the generality of plants. The divisions are but seldom arranged in any thing like a regular form; but sometimes they originate in pairs, and then the stem is said to be dichotomous, as in the Missletoe. Stems are also for the most part solid, but in some species they are found to be tubular, as in Water Hemlock; the tubular part being generally divided by thin and transverse partitions, as in Wild Angelica.

Position. Stems in the process of vegetation assume, for the most part, a vertical position, though not always strictly so; for there are many exceptions to this rule, some species affecting a position peculiar to themselves; ascending, not in an upright but in a zigzag direction, and the stems being hence denominated flaxuose, as in the case of *Celastrus buxifolius* (*Pl.* I. *Fig.* 6.); or, after ascending vertically for the greater part of their height, terminating at last in a curve, so as that the top bends down towards the ground. This last species botanists have designated by the appellation of the nodding stem, which may be exemplified in the case of Water Avens or the Musk Thistle. (*Pl.* I. *Fig.* 7.) Another exception is that of the creeping stem, which extends itself horizontally along the surface of the earth and sends down roots at regular intervals, as in the case of common Creeping Cinquefoil, or of Ground-ivy. Another familiar exception is that of the climbing stem, which attaches itself by means of roots, or other peculiar organs, to other plants or other bodies for support, not being of itself sufficiently strong to assume or maintain the upright position. Such are the stems of the Vine and Ivy. But the most elegant as well as most singular exception is that of the twining stem of botanists, which being too slender to support itself, ascends by twisting itself spirally around some other plant or prop. And what is most to be remarked, in the economy of such stems, is that the spiral twining is never effected at random, but always in a determinate manner in the same species; some stems twisting themselves round their prop in a direction from left to right (*Pl.* I. *Fig.* 9.), or according to the apparent motion of the sun, and never otherwise, as in the Honey-suckle and Black Briony (*Pl.* I. *Fig.* 10.); and others twisting themselves from right to left, or contrary to the apparent motion of the sun, and never otherwise, as in *Convolvulus sepium* or Great Bindweed.

Twining stem.

SUBSECTION II.

The Culm.—The culm or straw (*Pl.* I. *Fig.* 11.) is the trunk of the grasses, rushes, and several other plants nearly allied to them. In their figure such trunks are generally cylindrical, as in wheat and oats;

Figure.

HALLIDIE LIBRARY OF THE UNIVERSITY

but in some species of *Schœnus*, *Scirpus*, and Cypress-grass, they are triangular. In their structure they are generally hollow or tubular, as in the straw of Wheat: but in some genera they are solid, as in the straw of the Bulrush. The hollow straw is generally jointed with large swollen knots at the joints, as in Oats and Barley; but most of the rushes are without joints, though many of them are still tubular, having their transverse partitions at regular intervals without external knots. Some of the grasses have a peculiar and strongly marked bend at the knots, and then they are said to be knee-jointed, as *Alopecurus geniculatus*.

SUBSECTION III.

As distinguishable from the stem and culm.

The Stipe.—The stipe is a sort of secondary trunk (*Pl.* I. *Fig.* 12.), at least as applicable to the class of plants now under consideration, and is peculiar to Palms. It issues from the root or from the summit of the main stem, and supports the foliage, though it has but little that is analogous to the stem either in its shape or mode of growth; its shape being similar to that of leaves in its exhibiting two sides; and the shape of the main stem being that of the shaft of a column, cylindrical but without knots, and nearly of the same diameter throughout; as well as advancing in height by means of annual additions to the summit only, the diameter of the first year being the maximum.

SUBSECTION IV.

Surface.

General Remarks.—If trunks are viewed with regard to their surface they are smooth without any inequality or asperity, as in the Spurge-laurel and Bulrush; or they are rough and interspersed with rugged points and inequalities; or beset with stiff bristles, as in common Cow-parsnip and Viper's Bugloss; or with prickles or thorns, as in the rose and sloe-tree; or they are rift into clefts and chinks, as in the trunks of old trees.

Substance.

In their substance they are fleshy and succulent like the stem of the common House-leek; or they are fibrous, as the straw of the Bulrush; or they are firm and woody, as the trunk of the oak.

Size exemplified in the Palma altissima of Sloane.

In their size they are to be found of all dimensions, from that of the diminutive *Draba* that surmounts the parched wall, to that of the lofty mountain Palm that rears its head to the clouds. This immense and gigantic tree, the *Palma altissima* of Sloane, is a native of the West Indies, growing to the height of one hundred and twenty feet,* sometimes to the height of one hundred and fifty feet, and even, as it is said, to that of two hundred feet; being about seven feet in circumference at the base, but gradually tapering towards the summit, and thus forming with its lofty crown of fronds the noblest object of vegetable creation.

---

* Sloane's Nat. Hist. of Jamaica.

In our own country Oaks of a great age have been known to measure upwards of forty feet in circumference at the base of the trunk, with an elevation of ten or twelve feet without any division. At Colthorpe, near Wetherby in Yorkshire, there is now growing an Oak that measures seventy-eight feet in circumference close to the ground, and forty-eight feet at the height of a yard. It is said to have begun to decline in the reign of queen Elizabeth, and though now much in decay is still likely to stand for many years.

And Adansonia digitata.

But the trunk of the Baobab or African Calabash-tree, *Adansonia digitata*, is beyond all comparison the largest tree yet known. Adanson in his voyage to Senegal saw a tree of this species that measured seventy feet in height from the root to the top of the branches, the trunk being ten or twelve feet in height by twenty-seven feet in diameter;* a growth so enormous, that if the fact were not well authenticated we should be apt to regard it as altogether fabulous. The trunk of this immense tree is sometimes hollowed out and converted into a sort of house, serving for the abode of several families of negroes.

SECTION III.

The Branches.

Definition.

The branches are the divisions of the trunk originating generally in the upper extremity, but often also along the sides. The primary divisions are again subdivided into secondary divisions, and these again into still smaller divisions till they terminate at last in slender twigs. In point of external form and structure the branches resemble the trunk, but in point of insertion, distribution, and direction, they exhibit some considerable variety; furnishing a ground of distinction occasionally resorted to by botanists in the discriminating and characterizing of species.

---

* Fam. de Plant. Pref. ccxii.

Their distribution.

In their insertion and distribution they are opposite, that is growing in pairs, one on each side of the trunk and originating in the same horizontal plain, as in *Hypericum pulchrum*; or they are alternate, that is succeeding one another at certain intervals on opposite sides of the trunk, but not originating in the same horizontal plain, as in *Polygonum persicaria*; or they are verticillate, that is issuing from the trunk in whirls, and at regular intervals, as in the Scotch-fir (*Pl.* I. *Fig.* 13.); or they are decussated, that is growing in opposite pairs, of which each crosses the other alternately at right angles, as in Fuller's Teasel (*Pl.* I. *Fig.* 14.); or they are distichous, that is originating promiscuously on all parts of the stem, but turned chiefly in two opposite directions so as to form two rows, as in the smaller branches of the Yew-tree, or Silver-fir; or they are scattered, that is issuing promiscuously from all parts of the stem and diverging in all directions, as in the greater part of trees and shrubs; or they are fastigiate, that is of different lengths, and inserted promiscuously at different heights, but forming a flat tuft upon the top, as in *Dianthus barbatus.*

Position. In their position they are vertical, that is laying close to the stem, as in the poplar; or spreading, that is forming an acute angle with the upper part of the stem; or divergent, that is expanding horizontally or at right angles to the stem; or straddling, that is forming an obtuse angle with the upper part of the stem; or deflected, that is hanging down so as to form an arch, as in the weeping ash; or reflected, that is hanging down almost perpendicularly, as in the weeping willow; or retroflected, that is bent or twisted in various directions.

Size. In their size they are proportioned to the dimensions of the trunk, expanding in trees of large growth to a great distance from the centre, and forming a sort of secondary trunk. The horizontal branches of a full grown Calabash-tree are said to be from forty to fifty feet in length, thus forming a diameter of upwards of a hundred, and consequently a circumference of upwards of three hundred feet.*

---

* Famill. des Plant. Pref. ccxii.

SECTION IV.

The Leaf.

Its definition.

THE leaf, which is a temporary part of the plant, is a thin and flat substance of a green colour, issuing generally from the extremity of the branches, but sometimes also immediately from the stem or root, and distinguishable by the sight or touch into an upper and under surface, a base and an apex, with a midrib and lateral nerves. But to this definition there are no doubt a good many exceptions. For leaves are not always thin and flat, nor are they always green. The leaves of the Aloe and common House-leek are thick and fleshy, the leaves of the Beet are of a dark and dull purple; and the leaves of Canary Reed-grass are variegated with stripes of green and white. Nor are all leaves furnished with a midrib and lateral divisions; for in the Grasses the nerves are parallel.

Regions.

The point by which the leaf is attached to the plant is the base; the terminating point opposite is the apex; the intermediate body of the leaf is the expansion, and the boundary of the expansion is the margin. The base is sometimes merely a point in which the expansion originates, forming, as it were, part of the margin, and connecting the expansion immediately with the branch or stem. In this case the leaf is said to be sessile or sitting (*Pl.* II. *Fig.* 1.), as in that of Germander Speedwell and many others. But it often happens that the base is prolonged into a sort of pedicle, foot-stalk, or leaf-stalk, by which the expansion is removed to some distance from the point of attachment, as in the leaves of the Vine and Poplar. In this case the foot-stalk is denominated by botanists the petiole, and the leaf said to be petiolate. (*Pl.* II. *Fig.* 2.)

The petiole.

Its figure.

The figure of the petiole is generally semi-cylindrical, that is convex on the under surface, and flat or rather channelled on the upper; but in the leaves of the Vine and Ivy it is altogether cylindrical. Sometimes it is furnished with a sort of secondary expansion towards the base, by which it invests the stem, as in *Angelica sylvestris,* and then it is said to be winged. Sometimes it invests the stem throughout the whole of its extent, as in the Grasses, and then it is denominated the sheath. Sometimes it is shorter than the expansion, as in the leaf of the Elm; sometimes it is longer, as in the leaf of *Convolvulus sepium*; and sometimes it is of much the same length with the expansion, as in the leaf of the Poplar.

Simple petiole.

If the petiole supports but a single expansion it is always simple, and always to be regarded as constituting an integral part of the leaf. This identity is, I believe, not generally recognized by botanists. But it will require no great depth of observation to convince any one that, in the case now stated, the petiole and expansion constitute only one individual organ; the midrib of the expansion being merely a direct prolongation of the central fibres of the petiole, and the lateral nerves being merely ramifications of the midrib, or secondary, or divergent prolongations of the petiole; so that no separation of them can be effected without absolutely cutting or tearing them asunder. The point from which the fibres of the petiole begin to diverge is generally in the margin of the expansion; but in some leaves this point is placed in the centre, and the leaf said to be peltate or target-shaped (*Pl.* II. *Fig.* 3.), as that of the common *Nasturtium* or Indian Cress.

Supporting several expansions.

If the petiole supports several distinct expansions it is not always simple, and not always to be regarded as constituting an integral part of the leaf. The petiole of the leaf of the Horse Chesnut, which supports several distinct expansions, is indeed simple, but does not constitute an integral part of the leaf, at least in the rigorous sense in which the petiole supporting only a single expansion may be said to do; because the several expansions, which are indeed the real leaves, are not direct and immediate prolongations of the petiole, but distinct organs attached to it by a natural and conspicuous joint, at which, in the season of the leaf's fall, they spontaneously detach themselves from the petiole, in the same manner in which the petiole detaches itself from the tree.

Compound petiole.

But when the petiole supports several distinct expansions it is itself generally divided, or, in the language of botanists, compound. The portion from which the primary divisions proceed is called the primary petiole; the divisions thus formed are called the secondary petioles; and the subdivisions of these last are called the ternary petioles. Hence the principal distinctions which botanists have introduced into their descriptions of compound leaves. If the petiole is itself undivided but supporting several distinct expansions at the extremity as in the Strawberry, the leaf is said to be digitate. (*Pl.* II. *Fig.* 4.) If the leaflets or distinct expansions are arranged on opposite sides of the petiole as in the Pea and Vetch, the leaf is said to be winged. (*Pl.* II. *Fig.* 5.) If the insertions of the leaflets are opposite, the leaf is said to be oppositely winged, and if they are alternate it is said to be alternately winged. If the petiole supports an odd leaflet at the extremity, the leaf is said to be oddly winged; if it does not support an odd leaflet at the extremity it is said to be abruptly winged; and if the primary petiole is furnished with secondary petioles, which are again furnished with leaflets, or with ternary petioles, it is then said to be doubly or trebly winged as in the leaves of Fool's Parsley and Common Hemlock. (*Pl.* II. *Fig.* 6.)

Figure of the expansion.

The figure of the leaf or expansion has been found to be of great use to botanists in the discriminating of the different species of a genus; and the consequence is, that they have spared no pains nor labour to determine by observation and description the varieties of its form, of which they generally enumerate upwards of an hundred.

If the expansion is flat and membranaceous, the most frequent forms are the circular, the oval, the oblong, the triangular, the rhomboidal, the lanceolate, the tongue-shaped, the lyre-shaped. If they are thick and succulent, the most frequent forms are the cylindrical, the semi-cylindrical, the tubular, the sword-shaped, the compressed, that is thick and fleshy in the middle but flattened at the edges. The apex is very generally acute or pointed, but it is often also obtuse and sometimes appearing as if bitten or truncated, as in the leaves of *Epidendrum præmorsum* and the Tulip-tree. (*Pl.* II. *Fig.* 8.) The margin is entire, or cartilaginous, or undulated, or curled, or notched, or toothed, or serrated, or fringed, that is cut into fine and small segments, or set with strong hairs. But if the segments are large the figure of the expansion is more varied. Sometimes it is simply cleft, sometimes wing-cleft, sometimes lobed, and at other times it has the appearance of being torn or jagged, as in the leaf of *Senecio squalidus.* (*Pl.* II. *Fig.* 7.) But the figure of some leaves is altogether anomalous, and cannot be brought under any of the foregoing divisions, nor indeed under any other divisions that botanists have yet instituted, such as those of *Nepenthes distillatoria* (*Pl.* II. *Fig.* 9.), *Sarracenia purpurea* or Purple Side-saddle-flower (*Pl.* II. *Fig.* 10.), and *Dionæa Mucipula* or Venus's Flytrap (*Pl.* II.

Fig. 11.), which exhibit a singularity of structure unparalleled, as it appears, in the natural history of leaves.

The expansion, like the petiole, is generally distinguishable into an upper and under surface, of which the upper surface is generally flat or rather somewhat concave, and the under surface slightly convex, or perhaps even keeled by the longitudinal ridge of the midrib. The former is also more smooth than the latter, and of a deeper shade of green, as may be very distinctly perceived in the leaves of the Bramble and White Poplar. If the ramifications of the midrib are large and conspicuous, the leaf is said to be ribbed, as in the leaf of Water Plantain. (*Pl.* II. *Fig.* 12.) If the surface is much raised between the smaller divisions of the nerves, the leaf is said to be wrinkled, as in Scotch-kale; and if the surface is moulded into a number of overlapping folds, the leaf is said to be plaited, as in the beautiful leaf of Ladies' Mantle. (*Pl.* II. *Fig.* 13.)

Leaves characterized from their insertion.

If the leaf springs immediately from the root, it is said to be radical; if from the origin of the branches, it is axillary; if from the extremity of the branches, it is terminal. If it surrounds the stem or branch by its base, it is called an embracing leaf; and if it enfolds and invests the stem by its base, it is called a sheathing leaf, as in the Grasses.

And distribution.

The leaves, like the branches, are in their distribution opposite, or alternate, or tufted, or scattered, or in two rows, or in whirls, as in Ladies' Bed-straw. (*Pl.* II. *Fig.* 14.) Sometimes two or more are found to issue from the same point; sometimes they are all turned to one side of the stem, as in the genus *Convallaria* (*Pl.* II. *Fig.* 15.), and sometimes they are laid close to the stem and imbricated like the tiles of a house, as in *Erica vulgaris*.

Like the branches their direction is also vertical, or expanding, or horizontal, as in *Gentiana campestris;* or reflected, as in *Erica retorta;* or floating, as in the leaf of the Water Lily.

Size of leaves.

The size of the leaf as well as all the other qualities, varies according to the species of plant on which it grows. But it is not always the largest plant that has the largest leaf. The leaf of *Caltha palustris*, though an humble herb, is larger than the leaf of the Oak, though a lofty tree. The largest leaf produced on any British species of plant is, I believe, that of *Arctium Lappa*, or *Tussilago Petasites;* and yet it is scarcely fit to be compared with the leaves of many of the Exotics. The leaf of *Strelitzia regina* grows to the height of three or four feet by eighteen inches at the broadest, and yet there are others still larger. The leaves of the Banana or Plantain-tree have been known to grow to the extent of ten feet in length by two feet at the base;* so that some writers, owing perhaps to their extraordinary dimensions, have supposed them to be the leaves of which Adam and Eve are said to have made themselves aprons when they first felt the want of clothing; and to be the same with those denominated fig-leaves in the history of that transaction as related by Moses. The leaves of some of the Palms, in their compound dimensions, are frequently to be met with of the extent of from ten to fifteen feet in length; the length of the largest of the individual leaflets being three feet.

---

* Lour. Flor. Cochin.

The leaves, from their size or number, are naturally well calculated to form an agreeable and cooling shade, amidst the sultry heats of the tropical regions; where, as the shelter of some shade is most wanted, so the leaves of trees are found to be the largest, and are used in a variety of ways to screen the inhabitants from the rays of a vertical sun. And even in countries that are not within the tropics, the shade afforded by the leaves of trees is still extremely desirable during the heats of summer. Hence the celebrated groves of Academus where Plato and his successors delivered their lectures in philosophy; and the cool and shady avenues of Chesnut or Lime-trees, even in our own country, which are not yet entirely banished by the altered manners of modern times.

Odour. The odour of the leaf is oftentimes extremely grateful, particularly when bruised with the hand, as the leaf of *Myrtus Pimenta* or Jamaica Pepper will readily show. Some leaves will retain their aromatic flavour for several years even in a dried state, as may be exemplified in the case of *Verbena triphylla.* The leaves of many of the Geraniums are extremely sweet-scented, and the odour of the leaves of Mint and Balm is known to almost every body.

Uses.

The dietetical uses of vegetables are very often confined to the leaf, as may be exemplified in Cabbage, Cellery, and Lettuce, of which the leaves only are used for culinary purposes. The leaves of the Grasses are also the principal food of most quadrupeds; and there is scarcely a leaf of any plant whatever that is not fed upon by some insect. And so also the medical virtues of plants, as well as the dietetical uses, are found frequently to reside in the leaves, as may be exemplified in the case of Hemlock and Fox-glove, the most potent of simples, but of which the leaves only are used in pharmacy.

Lastly, as the leaf is only a temporary or deciduous part, it dies in the autumn or winter, and is regenerated in the succeeding spring. While it exists, however, it forms one of the principal ornaments of the plant, and is easily distinguished from the other parts. In the seasons of spring and summer it clothes the plant with verdure, and forms, by its expansion, a cool and inviting shade. And even in its decay and fall it ceases not to gratify the eye, assuming by slow degrees a paler and milder shade, and tinging the forest and the plain with an infinite variety of hues.

SECTION V.

The Frond.

As applied to palms.

THE frond, which is to be regarded as a compound of several of the parts already described, consists of an union or incorporation of the leaf, leaf-stalk, and branch or stem, forming as it were but one organ, of which the constituent parts do not separate spontaneously from one another by means of the fracture of any natural joint as in the case of plants in general, but adhere together even in their decay. Like the stipe, it is peculiar only to Palms, at least as applicable to perfect plants, and is sometimes pinnate, as in *Zamia integrifolia* (*Pl.* II. *Fig.* 16.), sometimes doubly pinnate, and sometimes fan-shaped and plaited, as in *Chamærops humilis* and *Raphis flabelliformis*.

It seems indeed, as well as the term stipe, to be going into disuse as applied to palms, and consequently as applied to the division of plants now under consideration. But as it was originally applied by Linnæus to the natural family of Palms, whose mode of leafing is singular and well described by the frond, I have thought it worthy of a place in this part of the book.

Does not the herbage of *Cactus Opuntia* constitute a frond?

CHAPTER II.

CONSERVATIVE APPENDAGES.

The conservative appendages are such accessory or supernumerary parts as are found to accompany the conservative organs occasionally, but not invariably. It is not meant, however, that they make their appearance at random. They are permanent in whatever species they are found to exist; some being peculiar to one species, and some to another. But they are never found to be all united in the same species, and are not necessarily included in the general idea of the plant. Where they occur however, they are often of the greatest utility to the botanist, and are accordingly worthy of a particular investigation. I shall now introduce them under the several following heads: gems, glands, tendrils, stipulæ, armature, pubescence, anomalies.

SECTION I.

Gems.

Their definition and species.

Gems are organized substances issuing from the surface of the plant, and containing the rudiments of new and additional parts which they protrude; or the rudiments of new individuals which they constitute by detaching themselves ultimately from the parent plant, and fixing themselves in the soil. Gems, according to Gœrtner, are of two sorts, simple and compound; simple if furnished with only a single envelope; and compound if furnished with two or more envelopes. Of each sort there are also two species, the former including the *Propago* and *Gongylus*—the latter, the bulb and bud, which last only are proper to perfect plants.

SUBSECTION I.

Its definition and varieties.

The Bulb.—The bulb is a compound gem of a tender and succulent substance, and of an oval or globular figure, situated upon the root, stem or branch, from which it ultimately and spontaneously detaches itself, and forms a new individual. If it is situated on the root it is said to be radical; and if upon the stem or branch it is said to be caulinary.

Radical bulb; its discription.

ARTICLE 1. *The Radical Bulb.*—The radical bulb has generally been regarded by botanists as constituting merely a root; and is still, I believe, often so regarded. But this view of the subject cannot be acknowledged to be sufficiently correct, except under the limitations stated in the former chapter, by which the term root was found to be applicable only to the fibres issuing from the base of the bulb. The bulb therefore is not a root; but as Linnæus has well characterized it, "It is the winter quarters of the future plant," furnished with a root suitable to its peculiar structure.

Varieties.

The following are the varieties of the radical bulb as enumerated by botanists. 1. The solid bulb (*Pl.* III. *Fig.* 1.), which consists of an entire and homogeneous mass of a firm and compact texture, as in the case of *Crocus sativus* and *Gladiolus communis;* though not in that of the Tulip, which has been often quoted as an example of this variety of bulb upon the authority even of Linnæus. But the remark has obviously originated in a mistake, as a very slight inspection will be sufficient to show. 2. The coated bulb (*Pl.* III. *Fig.* 2.), which consists of a succession of concave and concentric layers, enveloping and enveloped by one another, as in the bulb of the onion. In *Allium victorale* the coats, or layers, are so beautifully reticulated as to resemble a piece of fine and close net-work. 3. The scaly bulb (*Pl.* III. *Fig.* 3.), which consists of an assemblage of fleshy scales tiled one above another, but united only at the base, as in the bulb of the genus *Lilium.* 4. The lateral bulb, in which the shoot is protruded not from the apex or upper extremity, as is generally the case, but from the one side, as in *Allium Ampeloprasum.** 5. The double bulb, which consists of two single bulbs united together, as in the case of *Fritillaria pyrenaica.*† 6. The compound bulb, which consists of several individual bulbs united together, as in the case of *Allium nigrum.*‡

---

* Wid. Princ. Bot. p. 60.

† Ibid.

‡ Ibid.

The caulinary bulb.

ARTICLE 2. *The Caulinary Bulb.*—The caulinary bulb (*Pl.* III. *Fig.* 4.) consists of a number of small scales closely compacted together in an ovate or conical form, enclosing the rudiments of a future plant, and originating sometimes in the axil of the leaves, as in *Dentaria bulbifera*, and several liliaceous plants; and sometimes at the base of the umbel of flowers, as in *Allium carinatum* and others; in both which cases it is nourished by the parent plant till it has reached maturity, at which period the bond of connexion is dissolved and the bulb falls to the ground, endowed with the power of striking root in the soil by sending out fibres from the base, and so converting itself into a new individual.

ARTICLE 3. *General Remarks.*—Some bulbs are found to be useful as articles of food, or rather as giving a seasoning to food, such as the Onion, which is so very generally cultivated in our gardens; and some are found to be useful in medicine, such as the Squill or Sea-onion, so very well known for its bitter and nauseous taste.

To the botanist the figure, structure, or situation of the bulb, affords often a good and legitimate mark for the purpose of specific discrimination; and to the florist the cultivation of bulbs may fairly be said to be a mixing of the *utile* with the *dulce*, as no plants are more ornamental, and consequently more profitable to the cultivator, than plants with bulbous roots.

SUBSECTION II.

The Bud.—The bud is a compound gem of an ovate or conical figure, issuing from the axil of the leaves or extremity of the branches, and containing the rudiments of future branches, leaves, or fruit; but not detaching itself spontaneously from the plant and forming a new individual. It is composed externally of a number of concave and overlapping scales that protect the enclosed embryo from the injuries of the atmosphere, and is connected with the stem or branch by means of a short and fleshy pedicle in which the scales originate; the outer scales, which are occasionally fringed with hairs at the edge, being thicker and tougher in their fabric, and of a deeper colour on the external surface; and the inner scales, which are similar indeed in their structure, being finer and more delicate in their fabric and of a paler complexion. The bud of the American Walnut is said to be the most magnificent of all known examples; though the bud of *Æsculus Hippocastanum* or the Horse-chesnut, is I believe little inferiour.

Varieties.

Buds have been distributed by botanists into the three following varieties:—1. Such as produce only leaves.—2. Such as produce only flowers.—3. Such as produce both leaves and flowers together. This is a very well founded distinction, and the variety may generally be recognized by its form. The flower-bud is thick and short; the leaf-bud is slender and acute; and the bud producing both leaf and flower larger than either of the other. The two former varieties may be seen in the buds of the Peach-tree, in which the leaf-bud and flower-bud are always distinct; and the latter variety may be seen in the fruit-buds of the Horse-chesnut, which are always found to include both leaf and flower.

Mode of protrusion.

If two buds are protruded close together, it very often happens that each is of a different variety; and if three buds are so protruded, it sometimes happens that you have all the three varieties; and it has been further remarked that flower-buds which are protruded at a distance from leaf-buds, generally fall without producing fruit.

Some buds are protruded almost at right angles to the stem or branch, as those of the Fir-tree; while others are laid so close as to be altogether parallel to it, as those of the Willow. When they are protruded from the upper angle formed by the leaf and stem or branch, they are said to be axillary; and when they are protruded from the extremity of the stem or branch, they are said to be terminating. But the stem or branch of all plants is not always terminated in the same manner. It was an observation of Duhamel's that the stem or branches of plants whose leaves are alternate are generally terminated by a solitary bud; and that the stem or branch of plants whose leaves are opposite are generally terminated by three buds, of which the middle one is the largest.* Some buds are smooth on their external surface, as those of the Cherry; some are hairy, as those of the *Viburnum;* some are resinous, as those of the Horse-chesnut; and some are marked with angles, as those of the Walnut.

---

* Physique des Arbres, liv. ii. chap. i.

Not universal.

But all plants are not furnished with buds. Annuals have none. And even trees and shrubs, to which they are proper, do not produce buds in hot climates; because, perhaps, in hot climates the tender germe requires no covering to protect it. But in this country, and in all cold countries, trees and shrubs are universally furnished with buds; and without the intervention of a bud, no new part is added to the plant. In all cold countries therefore, buds are indispensable to the progress of vegetation; and yet they do not seem to be of any particular use to the botanist in the discrimination of the species, as being apparently altogether dependant upon climate. From their peculiarity of external form, however, in different species of plants they may serve occasionally to distinguish plants in the winter; and gardeners do in fact distinguish almost all their plants by the bud.

SECTION II.

Glands.

Description.

Glands are small and minute substances of various different forms found chiefly on the surface of the leaf and petiole, but often also on the other parts of the plant, and supposed to be organs of secretion. This was at least the opinion of Linnæus, who defined the gland to be "a little tumour secreting a fluid,*" which is in some cases no doubt the fact. From the extreme minuteness or apparent insignificance of vegetable glands, it was long before they attracted the attention of botanists, so as to be distinctly discriminated into species, and described according to their different forms. But this was at last effected by the industry of M. Guettard, a French physician and botanist, who first undertook the investigation of the subject, and characterized and distributed them as follows:†

Varieties. 1st. *The Miliary Gland.*—This species is so denominated from the supposed resemblance of the individuals contained under it to the miliary glands of animals—glands usually described as resembling grains of Millet seed. Sometimes they are crowded together in clusters, as in the Cypress; or arranged in regular sets, as in the leaves of the Fir.

2dly. *The Vescicular Gland.*—Glands of this species are small and membranaceous substances resembling transparent bladders. They are found on the leaves of the Myrtle and St. John's-wort.

3dly. *The Scaly Gland.*—This species has the appearance of thin and minute scales, which are generally of an oblong or circular figure, and are found on the frond of Ferns.

---

* Phil. Bot. sect. 84.

† Mem. de l' Acad. Royal. 1761.

4thly. *The Globular Gland.*—The glands included under this division have the appearance of small and minute globules, and are found chiefly on plants with labiate flowers.

5thly. *The Lenticular Gland.*—The figure of this gland is that of a lens more or less elongated. It is found on the young shoots of many trees, but particularly of the Birch.

6thly. *The Cup-shaped Gland.*—(*Pl.* III. *Fig.* 7.) This gland presents a cavity in the form of a cup, and is found on the petioles of the Apricot, Nectarine, and Passion-flower.

In some plants the glands are sessile, as those on the petiole of the Cherry; in others they are supported on a pedicle, as in the genus *Rosa.* (*Pl.* III. *Fig.* 6.)

Though the petiole is that part of the leaf on which they are most frequently situated, yet they are by no means confined to it. In the leaf of *Salix pentandra* they are situated between the serratures of the margin; in the leaf of the Tamarisk they originate in the under surface, and in the leaf of the Sundew they originate in the upper surface. The glands of the Moss-rose and Birch-tree are situated on the stem and branch.

The fluid secreted by the glands is in some cases resinous and fragrant, as in the glands of the Moss-rose; in others it is a sort of honied exudation, as in the glands of *Vipurnum Opulus*.*

Utility in botanical discrimination.

Linnæus regards the glands as affording good and legitimate marks of specific discrimination; and in the distribution of the species of some genera they are altogether indispensable. Thus they form the only sure mark of distinction between the Peach and Almond, otherwise so very similar that the one can scarcely be discriminated from the other. And yet the distinction is easily made with the aid of the glands. For the leaf of the Almond is beset with glands at the base which are situated between the serratures, while the leaf of the Peach has none.

SECTION III.

Tendrils.

Definition.

The tendril is a thread-shaped and generally spiral process issuing from the stem, branch, or petiole, and sometimes even from the expansion of the leaf itself; being an organ by which plants of weak and climbing stems attach themselves to other plants, or other substances for support; for which purpose it seems to be well fitted by nature, the tendril being much stronger than a branch of the same size.

---

* Smith's Intro. p. 226.

Modifications.

Sometimes the tendril is simple or undivided, as in that of *Lathyrus Aphaca* or Yellow Vetchling, and sometimes it is branched or compound, as in that of the genus *Vicia* (*Pl.* III. *Fig.* 8), thus multiplying its chances of meeting with support. If it issues from the stem or branch it is generally at the axil of the leaves; if from the petiole, at the extremity; and if from the leaf itself, at the apex, as in *Gloriosa superba* and *Flagellaria indica*, but in the Vine it issues from a point opposite to the insertion of the leaf. It is sometimes of use to the botanist in the discrimination of species, of which it enters even into the essential character, as in the genus *Lathyrus*.

Origin.

In its origin it is generally straight and in some cases still continues so, but in plants in which it is finally spiral it soon begins to assume the spiral form, extending itself to the nearest object of support, and twisting itself firmly around it, so as to prop up the plant till it can send out new tendrils to lay hold of objects still higher.

Anomalies.

In some plants the tendril, after completing a certain number of circumvolutions in one direction, twists itself spontaneously about and performs its future circumvolutions in a contrary direction. This is a phenomenon not easily accounted for. In the Virginian Creeper, *Hedera quinquefolia*, or, as Dr. Smith thinks it ought to be called, *Vitis quinquefolia*,* the tendril which issues from the axil of the leaves of a branched and spiral form terminates at last in a flat and fleshy process, by which it can attach itself, in default of better support, even to the surface of a brick or stone wall.

---

* Smith's Introduction, p. 225.

In the Common Ivy, *Hedera Helix*, the tendrils are not indeed spiral, but they are protruded all along the body of the stem or branches in the form of small fibres, at least on the side next to the supporter, insinuating themselves into the very body of it, if a vegetable, and fixing themselves as if real roots; and in default of vegetable support, clinging even to the naked wall and to the surface of the smoothest flint, and multiplying and attaching themselves firmly as the stem elongates, which thus often climbs to the summit of the loftiest trees, or to the battlements of the loftiest towers, covering the decayed trunk with a borrowed foliage, and giving beauty even to the mouldering ruin.

SECTION IV.

The Stipulæ.

Definition.

THE stipulæ are small and foliaceous appendages accompanying the real leaves and assuming the appearance of leaves in miniature. Malpighi is said to have been the first to observe and describe them, and to inquire into their uses in the vegetable economy.

Modifications.

Their figure is very much diversified in different species, but one of the most prevalent forms is that of the half arrow-shaped, as in the genus *Lathyrus* and many species of Willow. In the Grasses they are merely a sort of thin scale (*Pl.* III. *Fig.* 9.) crowning the sheath of the leaf, and with it investing the stem. In the genus *Pinus* they consist of a dry and scariose membrane (*Pl.* III. *Fig.* 10.) investing the leaves by the base. This is at least the case in such species as produce their leaves in pairs, as in *Pinus sylvestris*.

Sometimes the stipulæ are solitary, as in the Grasses; but they are for the most part protruded in pairs, one on each side the base of the expansion or foot-stalk, as in the Vetch and Weeping Willow. In the genus *Helianthemum* they are protruded in fours. In their insertion they are generally altogether distinct from the leaf; but in the genus *Rosa* and some others they are attached to it by the one side. There are also other varieties in the mode of their insertion, from which botanists have divided them into such as are extrafoliaceous and such as are intrafoliaceous; the former originating in the stem but rather below the insertion of the leaf, as in the cases already quoted; the latter originating in the stem also, but situated rather above the insertion, or in the axil of the leaf, as in *Prunus Padus* or Bird Cherry. In many plants, particularly of the natural order of *Rubiaceæ*, the stipulæ which are intrafoliaceous form a sort of tube or sheath investing the stem immediately above the insertion of the foot-stalk.* This is the case also in the genus *Polygonum.*

Some stipulæ are said to be deciduous, that is, they fall off almost as soon as the leaves are fully expanded, as those of *Liriodendron Tulipifera* or the Tulip-tree; but in general they fall only with the leaf, as in the Rose and Willow.

Utility in botanical discrimination.

The stipulæ are found by botanists to be of great importance in specific discrimination; and have been regarded as affording also a sufficient indication of the natural order and even genus to which any plant may belong. But this rule does not always hold good. For the stipulæ are not always present in all species of the same genus. In the *Cistus*, for example, some species are furnished with stipulæ while others are not.†

SECTION V.

Ramenta.

Their description.

RAMENTA are thin, oblong, and strap-shaped appendages of a brownish colour issuing from the surface of the plant, and somewhat resembling the stipulæ; but not necessarily accompanying the leaves. The term, which literally signifies bits of chips or shavings, seems to have been employed by Linnæus to denote the small and scattered scales that are frequently found on the stems of vegetables, originating in the bark and giving it a rough or chopped appearance. Hence a branch or stem that is covered with thin and dry scales or flaps is said to be ramentaceous, as in the case of *Tamarix Gallica* or French Tamarisk ; or, as in that of the Scotch-fir (*Pl.* III. *Fig.* 10.) and other Firs, producing their leaves in pairs, in which they accompany the stipulæ in the form of small scales, originating in the bark, and persisting after the leaves fall.

---

* Smith's Introduction, 219.

† Ibid. 220.

Indefinite application of the term.

But the term seems now to be applied to various other appendages, which do not even originate in the bark, or which are, at least, not persistent. It has been applied by some authors to the small and strap-like appendages which several of the *Begoniæ* bear on their leaves ; but which are scarcely perhaps entitled to the appellation.* It has been applied by Willdenow to several leaf-like appendages which he represents as being common to all plants whatever, under one modification or another, appearing about the time of the opening of the leaves, and falling, as he says, soon after.† It is possible, however, that this remark may have partly originated in the appearance assumed by the lower scales of the bud which invest the shoot by the base, and continue attached to it, in many plants, for a considerable time after the upper scales have fallen off.

But however this may be, the appendages attached to the young shoots of the Oak-tree, which he designates by the appellation of ramenta, seem to me to be decided stipulæ, issuing not only in pairs from the base of the foot-stalk, but being also quite green at their first appearance; and not always merely strap-shaped, but in many cases egg-oblong. They soon become brown, indeed, and fall; but so do many of the acknowledged stipulæ, which are evidently deciduous, if not rather caducous, and from which the appendages in question are not sufficiently distinct to justify their transference to the head of ramenta.

---

* Smith's Introduction, 227.

† Princip. of Bot. p. 48.

SECTION VI.

Armature.

Definition. THE armature consists of such accessory and auxiliary, parts as seem to have been intended by nature to defend the plant against the attacks of animals.

Stings. Sometimes this organ of defence is a sting, as in the case of the common Stinging Nettle (*Pl.* III. *Fig.* 11.), the sting of which is a slender and awl-shaped process of about one twentieth of an inch in length, originating in the outer rind and issuing generally at right angles both from the stem and leaf. It is acuminated into a fine point at the apex and dilated at the base, where it contains a secreted and venomous fluid which it discharges by the point when pressed; the point, from its extreme minuteness, penetrating, at the same time, the body that presses it. This is the rationalé of the stinging of the Nettle.

In *Malpighia urens* the sting is spindle-shaped, laying parallel to the surface of the leaf and fixed to it by the middle, the points being finely acuminated. Whether it secretes a fluid which is discharged by pressure, as in the sting of the Nettle, I have not been able to ascertain, as I have never seen it except in a dried state, and I do not recollect to have read any account of it in its vegetating state. But even in its dried state it is still troublesome enough to any one that handles it, for the points having now become stiff and rigid do the more readily penetrate the skin and fasten upon the hand that touches them.

Prickles.

Sometimes the organ of defence is a prickle, being a stiff and sharp-pointed process issuing from the stem or branch and originating in the bark, along with which it may be entirely stripped off. In some plants it is straight and upright, forming an acute angle with the upper part of the shoot or branch, as in the young shoots of the Barberry; in some it is also straight but issuing at right angles to the shoot or branch, as in the Gooseberry; in some it is said to be spiral, as in the genus *Hugonia;* in some it is reflected, as in the genus *Rosa* (*Pl.* III. *Fig.* 12.); and in some it is forked or divided, or growing in sets of two, three, or more, as in the Gooseberry and older branches of the Barberry.

Thorns.

Sometimes the organ of defence is a thorn, being a strong and rigid process issuing from the stem or branch, in which case it originates in the wood (*Pl.* I. *Fig.* 6.), or from the foot-stalk or expansion of the leaf, in which case it originates in the marginal or other nerves. The branches of the Sloe and Hawthorn afford examples of the former, and the leaves of the Holly-tree, *Robinia Pseudacacia,* and Aloe afford examples of the latter. The foot-stalks of *Astragalus Tragacantha,* and the stipulæ of *Xanthium spinosum* and the *Mimosæ,* which are persistent, are finally, when indurated by age, converted into real thorns.*

Terminal or lateral.

In some plants the thorn is terminal, as in *Riamnus catharticus ;* in some it is lateral, as in the Hawthorn ; in some it is simple and solitary, as in *Celastrus buxifolius ;* in some it is forked or divided, as in *Arduina bispinosa* (*Pl.* III. *Fig.* 13.) ; and in others it grows in sets of two, thee, or more together, as in *Gleditsia.*

Disappearing by cultivation.

§ 1. It has been observed by Linnæus and others that the thorn will sometimes disappear in consequence of cultivation. Thus *Pyrus sativa,* which in its wild state is furnished with strong thorns, is, in its cultivated state, found to be wholly without them. But this peculiarity is incidental only to the thorn, and does not affect the other species of armature, neither of which shows any tendency to disappear in consequence of cultivation. From the effects of culture upon the thorn in is liability to disappear altogether, one would have been apt to think it unfit for the purposes of specific discrimination. But botanists have not scrupled to accept of its assistance in cases of necessity, as well as of that of the prickle, which is indeed permanent. The former has been employed with success in the genus *Prunus*, and the latter in the genus *Rubus*.

---

* Smith's Introduction, p. 224.

2. Plants that are furnished with strong and numerous thorns, as they are well calculated, so they are often used, for the purpose of inclosing by quickset fences. Hence the utility of the Sloe, Hawthorn, Furze, and Holly-tree, forming when well trained a fence both durable and ornamental. In some species of *Mimosa* the thorns are so strong and thick set as to form a defence altogether impenetrable to the attacks of animals, except, perhaps, the rhinoceros; which is the less to be wondered at, as his skin is not only thicker and harder than that of the elephant, but is even said to be musket-shot proof.

SECTION VII.

Pubescence.

THE pubescence is a general term, including under it all sorts of vegetable down, or hairiness, with which the surface of the plant may be covered, finer, or less formidable, than the armature. Definition.

Some plants have their surface wholly smooth Microscopical.

and do not discover any traits of pubescence, even when inspected with the assistance of a lens. The Laurel and Lilac are of this discription. Others have their surface apparently smooth to the naked eye; but when viewed through a good magnifier they are found to be covered with a pubescence. In this case the pubescence is a sort of fine and impalpable down thinly scattered over the surface of the leaf or stem, as in *Coccus japonica* and *Potentilla reptans.*

Visible to the naked eye.

But in most plants the pubescence is discoverable both by the sight and touch, and in this case it assumes a great variety of aspects.

Modifications.

Sometimes it assumes the appearance of a fine dust or powder shook over the surface of the plant, as on the under surface of the leaves of *Coronilla glauca.* Sometimes it assumes the appearance of a fine and silky down laying straight and unentangled, and close to the surface, as in *Sophora argentea* and *Potentilla anserina.* Sometimes it assumes a cottony or velvet-like appearance, the hairs being somewhat interwoven together, as in *Gnaphalium arboreum* and *Althæa officinalis.* Sometimes it assumes a crisp and woolly appearance, the hairs being much curled up and closely matted together, as in *Origanum Dictamnus.* Sometimes it consists of a few and scattered, but very conspicuous hairs, as in *Hieracium Pilosella* (*Pl.* III. *Fig.* 14.) Sometimes the hairs are long and shaggy, as in *Galeopsis villosa ;* and sometimes they are stiff and bristly, and issuing from small and white tubercles imbedded in the surface of the leaf or stem, as in *Lycopsis arvensis* and *Echium vulgare.*

In their structure the hairs are generally cylindrical but tapering to a point, as in the Vetch and Mallow; or they are awl-shaped, as in *Begonia nitida;* or hatchet-shaped, as in the Hop; or hooked, as in Agrimony. They are also either simple, as in *Hieracium;* or forked, as in Lavender; or branched, as in the foot-stalk of the Gooseberry-leaf; or starred, as in *Alyssum;* or jointed, as in the Thistle.

Affected by cultivation.

The pubescence is extremely apt to change its appearance from soil, exposure, or culture; in consequence of which Linnæus regarded it as a ridiculous mark of specific distinction, except in cases of absolute necessity. But these cases of necessity have actually occurred; and Sir J. E. Smith has employed it with great success in the difficult task of distinguishing the different species of Mint;* as has also Dr. Roth † in distinguishing the different species of *Myosotis;* which, Proteus-like, had formerly eluded all sorts of attempts to subject it to the chains of specific discrimination, transforming itself, in its other features, into all possible shapes, but constant to none. Mr. Brown has likewise employed it with equal success in his elucidation of the Natural Order of the Proteaceæ of Jussieu.‡

---

* Trans. of Linn. Soc. vol. v.

† Flora Germanica.

‡ Lin. Trans. Vol. X. Part 1.

SECTION VIII.

Anomalies.

THERE are several other appendages proper to conservative organs which are so totally different from all the foregoing, that they cannot be classed with any of them; and so very circumscribed in their occurrence, that they do not yet seem to have been designated by any peculiar appellation. But as they are still well worthy of our notice from the very singularity they exhibit, as well as from their circumscribed occurrence, I shall here present them in one view, under the head of anomalies.

As occurring in Dionæa Muscipula.

The first anomaly I shall now mention as affecting the conservative appendages, occurs in *Dionæa Muscipula* or Venus's Fly-trap, being a flat and somewhat circular process issuing from the apex of the leaf, which is radical and somewhat battledore-shaped, and consisting of a midrib which is a prolongation of the midrib of the leaf, and of two elliptical lobes strongly toothed at the margin, giving it a slight resemblance to a steel trap with the wings expanded. This singular appendage, from which the specific name of the plant is derived, is so highly irritable that, if it is but touched with the point of any fine or sharp instrument, or if an insect but alights upon it, the lobes immediately collapse, as if eager to seize their prey and detain the insect captive; so that it resembles a trap, to which it has been compared, not only in form but in function.

A second is that which occurs in *Sarracenia purpurea* or Purple Side-saddle-flower; the leaves of which are cucullate, approaching to funnel-shaped, or rather pitcher-shaped reversed, so as to be capable of containing water; and are, besides, surmounted with a flattened concave and somewhat heart-shaped limb, originating in the apex or upper extremity of the expansion, and constituting an appendage that looks as if it were a secondary leaf growing out of the first. In Sarracenia purpurea.

A third, which is still more singular, occurs in *Nepenthes distillatoria.* The leaf of this plant, which is itself lanceolate, terminates at the summit in a thread-shaped pedicle; but supports on that pedicle a hollow and cylindrical or rather pitcher-shaped appendage, to which there is yet attached the curious and peculiar process of a lid opening at the one side. Nepenthes distillatoria.

The last anomaly I shall now specify is that of a small globular and membranaceous bag, attached as an appendage to the roots and leaves of some of the Aquatics. It is confined only to a few genera, but is to be seen in great abundance on the roots or leaves of the several species of *Utricularia* (*Pl.* III. *Fig.* 15.) inhabiting the ponds and ditches of this country; and on the leaves of *Aldrovanda vesciculosa*, an inhabitant of the marshes of Italy. In *Utricularia vulgaris* this appendage is pear-shaped, compressed with an open border at the small end, furnished with several slender fibres originating in the margin, and containing a transparent and watery fluid, and a small bubble of air, by means of which it seems to acquire a buoyancy that suspends it in the water.*

CHAPTER III.

REPRODUCTIVE ORGANS.

THE reproductive organs are such parts of the plant as are essential to its propagation, corresponding in extent to the fructification of Linnæus, which he has elegantly defined to be a temporary part of the vegetable, whose object is the reproduction of the species, terminating the old individual and beginning the new.† It includes the flower with its immediate accompaniments or peculiarities, the flower-stalk, receptacle, and inflorescence; together with the ovary or fruit.

SECTION I.

The Flower.

Its definition.

THE flower, like the leaf, is a temporary part of the plant issuing generally from the extremity of the branches, but sometimes also from the root, stem, and even leaf; being the apparatus destined by nature for the production of the fruit, and being also distinguishable for the most part by the brilliancy of its colouring or the sweetness of its smell. It has been happily styled by Pliny * the joy of plants, "*Flos gaudium arborum;*" of which the Lily, the Tulip, and the Rose, are magnificent examples.

---

* With. Arrang. ii. 19.

† Phil. Bot. sec. 86.

Mode of attachment.

In its mode of attachment the flower is either sessile, as in Agrimony; or supported upon a *flower-stalk*, generally denominated the peduncle, as in *Linnæa borealis*. In their direction flowers are upright, as in *Silene quinque vulnera;* or bending, as in *Bidens cernua;* or nodding, as in *Carduus nutans;* or unilateral, that is attached to one side only of the stem, as in the Lily of the Valley; or distichous, that is distributed in two opposite rows, as in many of the Grasses; or homosestrophous, that is attached to two opposite sides, but turning themselves about ultimately to the one side, as in *Festuca rubra.* In their insertion they are radical, that is issuing from the root, as in the Primrose; caulinary, that is issuing from the stem, as in *Verbascum;* rameal, that is issuing from the branch, as in the Cherry; or foliary, that is issuing from the leaf, as in *Ruscus.* If they originate in the extremity of the branch or stem, they are said to be terminal, as in the Thistle; if in the upper angle formed by the leaf or branch, they are said to be axillary, as in Fringed Buckbean.

Direction, distribution, and insertion.

---

* Hist. Mund. Lib. xvi. chap. xxv.

But flowers, when inspected minutely and individually, are obviously divisible into several different and distinct parts. Perfect flowers consist generally of the four following: the calyx, the corolla, the stamens, and the pistil, which shall form the subject of the four following subsections.

SUBSECTION I.

Definition.

The Calyx.—The calyx is the exterior envelope of the flower, encompassing and protecting the interior parts. It may be perceived very distinctly in a rose not yet fully blown. It does not however, universally and of necessity, form a constituent part of the flower; for in some flowers, as in the Tulip, it is altogether wanting. But in the flowers of perfect plants it is very generally present, in its application to which Linnæus regarded it as consisting of the five following species: the perianth, the amentum, the spathe, the involucrum, the glume. But this division does not upon minute inspection turn out to be very correct. For of all the species here enumerated the perianth and glume seem alone entitled to the appellation of calyx. The involucre and spathe are more nearly allied to leaves than to the calyx; and the ament, though it contains a calyx which is generally distinguished by the appellation of the scale, is not yet itself a calyx. The division of Linnæus therefore will not be adopted, but the parts designated by the different names will be introduced in their proper places, and the calyx of perfect plants discriminated into the three following species: the perianth, the glume, and the scale. Species.

ARTICLE 1. *The Perianth.*—The perianth, which is by far the most common species of calyx, and like the leaf very generally green, invests the flower immediately, so as to constitute a part of it, and to form a sort of circular integument slightly resembling a cup. From this resemblance it is frequently, and sometimes also accurately enough, denominated the flower cup, as may be examplified in the case of the Acorn, the perianth of which constitutes a perfect cup.

The perianth, or cup investing the flower, is either proper or common. It is proper if it constitutes with the contained parts only a single flower, as in *Primula* (*Pl.* IV. *Fig.* 1.), and common if with the contained parts it constitutes more than a single flower, as in *Tragopogon.* (*Pl.* IV. *Fig.* 2.)

The proper perianth or calyx consists either of one individual piece, as in the Primrose; or of several distinct pieces, as in the genus *Rumex.* If it consists of a single piece it is said to be monophyllous; and if of more than a single piece it is said to be diphyllous, triphyllus, or tetraphyllous, according to the number of distinct pieces of which it may happen to consist. Proper.

Mono-phyllous.

The monophyllous calyx, which is exemplified in the Primrose, is generally regarded as consisting of three parts—the tube, the mouth, and the border. The tube is the lower and somewhat cylindrical part; the mouth is the upper extremity of the tube; and the border is the part which extends beyond the mouth of the tube, sometimes entire, as in *Matthiola scabra*, and sometimes divided into segments, in which case it is in some species cleft down to the middle, as in the Rose; in others it is cleft down almost to the base, as in the Lime-tree; and in others it is divided into an under and upper segment, suggesting the idea of lips, and characterized by the term labiate, as in the genus *Thymus*.

Polyphyllous.

The proper and polyphyllous calyx is either single or double. It is single if it consists of only one set of distinct pieces, as in the genus *Linum*; double if it consists of two distinct sets, the one enveloping the other, as in the Common Mallow.

In some plants the proper calyx is thin and membranaceous, as in *Convolvulus sepium*; in others it is thick and fleshy, as in the Rose. Its figure is cylindrical, as in the Pink; or prism-shaped, as in *Pulmonaria*; or bell shaped as in *Convolvulus*; or pitcher-shaped, as in the Rose; or it is inflated, being merely distended in the middle, but contracted at the extremities, as in the genus *Silene* or Catch-fly.

It is said to be shut if the segments are applied close to the flower, as in the genus *Cheiranthus;* or spreading, if the segments expand towards the point, as in the Raspberry; or reflected if the segments are bent back at the point, as in *Ranunculus bulbosus.*

If it falls before the other parts of the flower it is said to be caducous, as in the Poppy; if it falls with the other parts of the flower it is said to be deciduous, as in the Lime-tree; and if it remains after the other parts of the flower fall, it is said to be permanent, as in St. John's Wort.

Adherent or detached.

In its attachment the calyx is adherent, that is closely investing the ovary by the lower part, but surmounting it by the border, as in Enchanter's Nightshade; or it is half adherent, investing part of the ovary, as in Clustered Alpine Saxifrage; or it is detached, that is including the ovary, but not adhering to it, as in the Primrose.

The adherent and detached calyx are also designated by the terms superior and inferior calyx. But according to M. Ventenat, the calyx always originates beneath the ovary, and when it is thought to originate above it, or to be superior, it is only because the lower part adheres so closely to the fruit as to be scarely distinguishable from it.*

Common.

The common perianth or calyx is either mono-

---

* Tab. du Reg. Veget.

phyllous, that is consisting of one piece divided into several segments which are united at the base, or it is polyphyllous, that is consisting of several distinct pieces, as in Goat's-beard. It is also either simple, that is polyphyllous with the pieces arranged in one circular row, as in Goat's-beard; or double, that is being itself enclosed in a secondary calyx, as in Ox-tongue. It is scaly, that is consisting of a number of closely imbricated scales, as in the Thistle; or calyculate, that is imbricated with a circular row of scales, at the base resembling an exterior calyx, as in Wild Succory; or squarrose, that is having the scales reflected at the points, as in *Arctium;* or fringed, that is having the margin of the scales set with short bristles of equal length, as in Black Knapweed; or muricated, that is having the margin of the scales set with sharp prickles, as in Rough Hawk's-beard; or thorny, that is having the scales furnished with thorns, as in Common Star Thistle. It is spherical, as in Burdock; or hemispherical, as in the Daisy; or egg-shaped, as in *Achillæa;* or oblong, as in Hemp-agrimony.

Definition.

ARTICLE 2. *The Glume.*—The glume is a chaffy and membranaceous substance accompanying the flowers of Grasses, and constituting their calyx, but not so formed as to constitute a cup. Sometimes it consists of one piece only, and sometimes of two distinct pieces called valves. If it consists of one piece only, as in *Lolium*, it is said to be one-valved (*Pl.* IV. *Fig.* 3.); and if of two pieces, as in *Avena*, and most other Grasses, it is said to be two-valved (*Pl.* IV. *Fig.* 4.). The figure of the valves is oval, as in *Scirpus maritimus;* or lanceolate, as in *Poa cæsia;* or concave, as in *Briza;* or keeled, that is having a prominent and longitudinal ridge on the under side, as in *Cynosurus cristatus;* or blunt, as in *Briza minor;* or acuminate, as in *Poa nemoralis;* or fringed, as in *Festuca rubra.* The surface is smooth, as in *Festuca ovina;* or rough, as in *Cynosurus echinatus;* or streaked, as in *Poa minor;* or nerved, as in *Bromus arvensis;* or coloured, that is of any colour but green, as in *Melica.* It is either one-flowered, as in *Agrostis;* or two-flowered, as in *Aira;* or three-flowered, as in *Sesleria;* or many-flowered as in *Bromus;* and is consequently like the perianth either proper or common.

ARTICLE 3. *The Scale.*—The scale is a thin, chaffy and membranaceous substance, though sometimes also tough and leathery, forming part of the fructification of a variety of plants producing incomplete flowers, and constituting their calyx. It may be exemplified in the aggregate flowers of the Willow and Fir, in the former of which it is a proper calyx, each scale including an individual flower; and in the latter, a common calyx, each scale including more than an individual flower. Definition.

The figure of the scale is either circular, as in Its figure.

Salix herbacea (*Pl.* IV. *Fig.* 5.); or ovate, as in *Salix acuminata;* or lanceolate, as in *Salix sphacelata;* or linear, as in *Salix Russeliana.* It is also either entire, as in the Fir; or fringed, as in *Salix herbacea;* or emarginate, as in *Salix petiolaris;* or cleft, as in *Betula nana.* (*Pl.* IV. *Fig.* 6.) Its surface is smooth, as in *Salix amygdalina;* or pubescent, as in the Hazel; or silky, as in *Salix argentea;* or hairy, as in *Salix purpurea.* It is deciduous if it falls with the flower, as in *Betula alba;* and permanent if it adheres to the fruit, as in the Fig.

Respecting generic characters.

ARTICLE 4. *General Remarks.*—As the conservative organs have been found to furnish marks proper for the discrimination of species; so the reproductive organs, or their parts, have been found to furnish marks proper for the discrimination of genera. This peculiar aptitude of the reproductive organs had been discerned, obscurely at least, even by the earlier systematic Botanists; but was first distinctly perceived and pointed out by the illustrious Tournefort, who formed many of his genera on the parts of the fructification, availing himself of the aid of the conservative organs, only in what he conceived to be cases of necessity. But Linnæus, from whose profound investigations, and extensive as well as accurate views, botany was destined to derive still farther improvement, regarded the reproductive organs as constituting exclusively the only sure and legitimate ground of generic discrimination, and demonstrated their sufficiency in all cases whatever; and hence the peculiarities of the calyx, when present, are often of eminent use in the determination of genera.

SUBSECTION II.

Definition.

The Corolla.—The corolla is the interior envelope of the flower, investing the central parts, but invested by the calyx. It is generally of a finer and much more delicate texture than the calyx, and is of all the parts of the fructification the most showy and ornamental, being always, or with but few exceptions, that which is the most highly coloured, and hence vulgarly regarded as alone constituting the flower, as well as that from which the flower imparts its rich and fragrant perfume, delighting at the same time both the sight and smell. To this most elegant part of the fructification the term corolla has been very happily applied by Linnæus, signifying as it does in the original, a crown or chaplet of flowers.

If in the composition of the flower, an individual calyx invests an individual corolla, as in the Cowslip or *Convolvulus*, the flower is said to be *simple*. But if an individual calyx invests an assemblage of individual corollas, as in the Daisy and Dandelion, the flower is then said to be *com-*

pound, and the corollas contained in the calyx are generally denominated florets.

Modifications.

Like the calyx the corolla consists either of a single piece, as in *Campanula* (*Pl.* IV. *Fig.* 7.); or of several distinct pieces, called petals, as in *Galanthus*. (*Pl.* IV. *Fig.* 8.) If it consists in a single piece, it is said to be monapetalous; if of more than one piece, it is said to be dipetalous, tripetalous, or polypetalous, according to the number of distinct pieces. It is to be remarked however, that in the husk-like corolla of the grasses, as in their husk-like calyx, the petals are denominated valves, which differ from those of the calyx only in their being proper to a single flower, or in their immediately investing the ovary.

Monopetalous.

The monopetalous corolla, like the monophyllous calyx, is divided also into three parts—the tube, the mouth, and the border. The tube is upright and cylindrical, as in the Periwinkle and Primrose; or it is bent and crooked, as in *Lycopsis arvensis;* or inflated, as in *Orobanche ramosa*; or appendicled, that is furnished with leaf-like appendages, as in *Cuscuta europæa*. The mouth is frequently beset with fine hairs, or small projecting scales, in which case it is said to be shut, as in *Cynoglossum officinale;* or it is entirely without hairs or scales, in which case it is said to be open or naked, as in *Echium vulgare*. The border is erect, or rather concave, as in the Cowslip; or it is flat and expanding, as in the Primrose; or it is twisted, as in the Periwinkle; or cleft, as in *Anagallis.* If the segments into which the border is cleft are equal, the corolla is said to be regular, as in *Solanum tuberosum;* and if they are unequal, it is said to be irregular, as in *Echium vulgare.* The irregular border is sometimes divided into two principal parts called lips, as was the case also in the calyx, giving origin to the denomination of Labiate flowers. The upper lip is again oftentimes subdivided into two smaller segments, and the under lip into three, as in *Verbena officinalis.*

Such is the character of the several parts of the monopetalous corolla taken in detail; but botanists have found it necessary to attend also to the general outline of the whole, as constituting one individual organ. The following are the most frequent forms.

Regular. The regular monopetalous corolla is tubular, but somewhat dilated at the orifice, as in many of the Heaths; or bell-shaped, as in *Campanula;* or globular, as in the Arbutus; or club-shaped, as in *Erica tubiflora;* or funnel-shaped, as in *Pulmonaria;* or cup-shaped, as in *Simphytum officinale;* or salver-shaped, as in *Hottonia;* or wheel-shaped, as in *Anagallis.*

Irregular. The irregular monopetalous corolla is difform, that is tubular, but expanding towards the summit, and divided into several unequal segments, as in Bluebottle; or semiflosculous, that is tubular at the base, but terminating in a strap-shaped border, as in the florets of the Dandelion and many of the compound flowers; or labiate, that is divided into segments resembling lips, as in Woundwort and Wood Betony; or ringent, that is labiate, and exhibiting a slight resemblance to the open mouth of an animal, as in common Skull-cap; or personate, that is ringent in form, but having the mouth shut, as in Snap-dragon.

Polypetalous. The individual petals of the polypetalous corolla are, like the monopetalous corolla itself, divisible into distinct parts; which in the present case are, however, only two—the claw and the border. The claw is the lower portion of the petal; the border is the upper portion. In some petals the claw is extremely short, serving merely as a point of attachment to the receptacle, as in the Rose; in others it is long and conspicuous, as in the Pink. The border is upright, as in *Arabis stricta;* or expanding, as in *Silene nutans;* or horizontal, as in *Arabis hispida.* The petals are also equal or unequal in their size or shape, constituting, like the segments of the monopetalous corolla, regular and irregular flowers.

Sometimes a tetrapetalous corolla has its petals so disposed as to exhibit a slight resemblance to a cross (*Pl.* IV. *Fig.* 9.), in which case the flower is said to be cruciform; and may be exemplified in the Stock or Wall-flower. Sometimes the petals of a tetrapetalous corolla are irregular, and disposed so as to exhibit a slight resemblance to a butterfly, in which case the flower is said to be papilionaceous, and is exemplified in the Pea and Bean (*Pl.* IV. *Fig.* 10.); the petals of which, and of all similar flowers, are so peculiar in their form or position as to have received distinct appellations. The upper petal, which is generally large with an erect border, is denominated the *standard.* The lower petal, which is situated opposite to the standard, and hollowed out in the form of a boat, is denominated the *keel.* And the two remaining petals, which are situated in an opposite position, one on each side of the keel, are denominated the *wings.*

If the corolla is inserted in the receptacle, that is underneath the ovary, as in *Convolvulus,* it is said to be *Hy-pogynous;* if it is inserted in the calyx, or integument surrounding the ovary, as in the genus *Ribes* and many others, it is said to be *Perigynous*; and if it is inserted upon the ovary, as in the genus *Scabiosa,* it is said to be *Epigynous.* Insertion.

If it is longer than the calyx it is said to be large, as in *Convolvulus sepium;* if it is shorter than the calyx it is said to be small, as in *Fragraria vesca;* and if it is of the same length with the calyx it is said to be of a moderate size, as in *Fragraria sterilis.*

If the corolla falls before the stamina, or organs which it immediately invests, it is said to be caducous or fugacious, as in *Cistus ledifolius;* if it falls with the stamina it is said to be deciduous, as in St. John's-wort; and if it remains after the stamina have fallen, it is said to be permanent or persistent, as in the Star of Bethlehem.

The colour of the corolla is in some flowers a beautiful white, as in the elegant blossoms of the Guelder Rose and Magnolia; in some it is red, as in many of the Roses; in some it is yellow, as in *Caltha palustris;* in some it is blue, as in Germander Speedwell; in some it is violet, as in common Nightshade; and in some it is purple, as in Foxglove.

How distinguished from the calyx.

The corolla, like the calyx, is not at all absolutely essential to the botanical notion of a flower, and is accordingly sometimes wanting. When present, however, it affords also, like the calyx, the most unexceptionable marks of generic discrimination, arising either from the mode of its insertion, or from the peculiarities of its figure, or from its character, as consisting of one or more petals. If the calyx and corolla (the exterior and interior envelopes of the flower) are both present, the flower is said to be complete, and the distinction between the two envelopes is obvious.

But if one envelope only is present, as in the Tulip and liliaceous plants in general, and the other altogether wanting, the flower is then said to be incomplete; and a question naturally arises with regard to the true character of this solitary envelope: Is it a calyx or corolla? The solution of this question has been the subject of a great deal of botanical doubt and discussion, without having produced any rule of distinction that can be regarded as altogether satisfactory or as applicable to all existing cases. The truth is, that nature has not distinguished the organs in question by any very obvious or decisive limits. The one is, indeed, generally green and the other generally coloured. But to this rule there are a good many exceptions. The calyx of *Daphne Laureola* is yellow, and the corolla green. The calyx of *Fuschia coccinea* is of a bright scarlet, the corolla indigo. The calyx and corolla of *Daphne Mezereum* are not only both coloured, but are even united at the margin so as to form but one piece. What then is the essential character by which each is to be discriminated, and by which we are to be guided in the case of the absence of either ?

If one envelope only is present, some have thought that it must of necessity be the calyx, because that is the primary part; and others have thought that it must of necessity be the corolla, because that part is the more noble. But these distinctions are altogether fanciful, and without any foundation in the arrangements of nature. Another rule of distinction suggested by Ray* was, that the corolla is deciduous and the calyx permanent; and the rule is, no doubt, of pretty general application, but is loaded with by far too many exceptions to be a good one. In the Poppy the calyx falls before the blossom, and in the Hyacinth and Star of Bethlehem the

By Ray.

---

* Hist. Plant. lib. i. chap. x.

corolla is persistent. An attempt was made to strengthen the rule by adding that the petals of the corolla are thinner and more delicate than the divisions of the calyx. But although this is also very generally the case, the fact is occasionally quite the reverse, as is evident from several of the preceding examples, in which the calyx has more the appearance of a corolla than the corolla itself; as well as from the single envelope of the genus *Polygonum* and some others, which seems to participate partly of the nature of calyx and partly of the nature of corolla; the divisions being green and fleshy throughout the great part of their extent, but thin and finely coloured on the margin.

By Linnæus.

It had been an opinion of Cæsalpinus that the calyx is merely a continuation of the outer bark of the plant or flower-stalk; and upon this foundation Linnæus establishes a test apparently sufficient to distinguish the calyx from the corolla in all doubtful cases. For, improving upon the notion of Cæsalpinus, he apprehended that as the calyx is a continuation of the outer bark of the plant or flower-stalk, so the corolla is a continuation of the inner bark. And hence, if of these two organs one only is present, you have but to ascertain in what part of the bark it originates, in order to say which it is. This summary and decisive test looks indeed very beautiful in theory; but the observations of the acute and sagacious Hedwig have shown that it is not founded in fact.

Indeed it cannot be true that the corolla is a continuation of the *liber* or inner bark, in cases in which it is inserted in the calyx, if it be true that the calyx is itself a continuation of the outer bark, as the rule implies. And if the corolla that is inserted in the calyx is not a continuation of the inner bark, of what then is it a continuation? Of the calyx evidently, which is, by hypothesis, a continuation of the outer bark. But if an acknowledged corolla may, like an acknowledged calyx, originate in the outer bark, then I cannot tell whether the single envelope is to be called calyx or corolla, even though it should so originate. The rule is consequently good for nothing.

Linnæus does not indeed impose it as a rule of practice, being furnished with what he might, perhaps, regard as a better; though the distinction is both clearly and confidently stated in his work.* But it has been since adopted, with all its imperfections upon its head, as the grand test of discrimination in this doubtful case, even by the celebrated Jussieu himself, the first botanist of the present age. In consequence of the adoption of this opinion, Jussieu has been led to regard as a calyx the beautiful blossom of the Tulip and other liliaceous plants, which has been, by the common consent of almost all other botanists whatever, regarded as a corolla.

In order to get rid of the difficulty, some botanists have adopted the plan of designating the organs in question merely by the general appellation of *Perigynandra,** or *Perigonium,*† signifying by such appellation the covering of the stamens and pestils, or central organs of the flower; and describing the envelope as single, if of the organs designated by the terms calyx and corolla one only is present; and as double, that is furnished with an outer and inner envelope, if both organs are present.

---

* Phil. Bot. sect. 86.

But owing to the very obvious marks of distinction existing between the calyx and corolla in the flowers of most plants, as well as to their performing functions perhaps altogether different in the vegetable economy, the mode of including both under one general appellation is not nearly so satisfactory as that of designating each by a proper name, and does not seem to have met with much approbation.

By Ventenat.

Ventenat has suggested a rule founded upon the internal structure of the calyx and corolla; and Linnæus has founded his main rule upon the relative situation of the stamens of that of the calyx and corolla; but as an examination of the merits of these rules would be premature in the present section, depending as they do on parts not yet described, and with which the reader is supposed to be not yet acquainted, I shall only observe that they are liable to the same objections with the rules already stated; so that our best guide, after all that has been said on the subject, is, perhaps, that of analogy, which we are often obliged to content ourselves with in cases even of greater importance. Thus the flower of the Poppy has both envelopes, the calyx and corolla. The flower of the Tulip has but one. Which of them is it? But the part that is present in the Tulip resembles the corolla of the Poppy, more than it does the calyx. The conclusion therefore must be that it is a corolla. And if there are cases in which the single envelope seems to partake of the nature both of corolla and calyx, there is no inconsistency whatever in supposing them combined in one.

---

* Neckar. † Hedwig.

After all there are cases in which even the rule of analogy will not enable us to decide the question. I may exemplify that of the White Lily, in which the single envelope is at first perfectly green, and similar by analogy to a calyx; although it changes afterwards to a beautiful white and assumes the appearance of a corolla. Hence the opinion of Jussieu is not so unreasonable as it has been thought to be, countenanced as it is by the above fact, or by similar facts, as also by the sanction of botanists peculiarly well qualified to judge of its merits.* His definition of the calyx † and corolla has indeed been strongly reprobated by Mr. Salisbury,‡ a botanist well known for his acuteness of argument and remark, and certainly it cannot be defended in its full extent. But the definition that Mr. Salisbury has substituted in its place is itself equally faulty, and is as complete a *petitio principii* as ever was made; a proposition not duly sanctioned by facts being first laid down as a rule, and then all envelopes reduced to it as an infallible standard, like the bodies of the unwary travellers to the iron bed of Procrustes. The calyx, says Mr. Salisbury, is the external envelope of the flower, similar to the plant, for the most part, in colour and substance, inserted in the torus (receptacle) and always distinct from the stamens. But this is the assuming of the very point in question, for Jussieu has said that the stamens *may* be inserted in the calyx, and it will appear in the sequel that they are occasionally so inserted.

---

* Brown on Proteaceæ. Lin. Trans. vol. x. pt. i.

† Gen. Plant. Præf.

‡ Lin. Trans. vol. viii.

SUBSECTION III.

Definition.

The Stamens.—The stamens are substances of a very slender fabric and of a thread-shaped figure, surmounted with a small bag or *viscus*, and situated immediately within the corolla, to which they are sometimes even attached by the inner surface. A very good example of them may be seen by opening up the blossom of a Tulip or a Lily. (*Pl.* IV. *Fig.* 11.) They are apparently of no importance to the vulgar observer, but are essential to the botanical notion of a flower, because indispensable to the formation of perfect fruit. The calyx is sometimes wanting, as in *Callitriche;* and the corolla sometimes wanting, as in *Hippuris;* or the calyx and corolla are both wanting, as in *Chara;* but the stamens are never wanting, except from adventitious or accidental causes.

Some flowers are furnished with only one stamen, as in the genus *Hippuris;* others are furnished with two stamens, as in *Veronica;* others with three, as in the Grasses; and so on in arithmetical progression till you reach the number ten or twelve; after which their number is generally found to be indefinite, amounting, however, in some cases to upwards of a thousand. On the number of the stamens Linnæus has founded the first twelve classes of his artificial method; so that if any flower is furnished with only one stamen it is to be referred to the first class; if with two stamens to the second class; if with three to the third class, and so on in succession. The remaining classes are founded on other peculiarities. Number.

But, perhaps, there is no peculiarity of the stamens of more essential importance to the botanist than that of the mode of their insertion; affording, as it does, one of the most approved characters in the discriminating and establishing of genera, and particularly in the investigation of natural affinities. The following are the different modes of insertion as specified by botanists. If the stamens are inserted in the receptacle, as in the genus *Ranunculus,* their insertion is said to be *Hypogynous;* if in the Insertion.

corolla, as in the genus *Veronica*, their insertion is said to be *Epipetalous;* if in the calyx, as in the genus *Epilobium*, their insertion is said to be *Perigynous;* and if on the ovary, as in the natural order of the *Orchideæ*, their insertion is said to be *Epigynous.*

Proportions.

The relative proportion of the stamens to one another, and to the several parts of the flower, is also a circumstance of material importance to the botanist. In the Tulip, and indeed in most genera of plants, they are nearly of the same length in the same flower. But there are also many genera in which they are uniformly of unequal lengths in the same flower. This is the case in the genus *Mentha*, in which out of four stamens, the complement of the flower, two are always shorter; as well as in all genera of the class *Didynamia* of Linnæus, comprehending the natural order of the labiate, ringent, or personate flowers. The same remark may be applied to the class *Tetradynamia* of Linnæus, in which out of six stamens, the complement of the flower, two are also always shorter, being one of the most striking characteristics of the very natural order of cruciform flowers. If compared in their proportions with the other parts of the flower, the stamens are sometimes found to equal the calyx or corolla in their length, as in the genus *Polygonum;* sometimes they are found to overtop it, as in *Allium vineale;* and sometimes they are found to fall short of it, as in *Crocus sativus.*

In their aggregation they are distant, as in *Lycopus europæus;* or contiguous, as in the Raspberry; or crowded, as in *Ranunculus;* or imbricated, that is overlapping one another like the tiles of a roof, as in *Magnolia.* In their position they are opposite, that is facing the petals, as in the Lily; or alternate, that is inserted between the petals and facing the divisions or segments of the calyx, as in Borage. Aggregation.

On this last circumstance Linnæus founds his rule for distinguishing the calyx from the corolla, which is as follows: The stamens alternate with the segments of the corolla, but face the segments of the calyx.* This rule holds good, no doubt, in a great many cases, but is, like all other rules on the subject, loaded with a variety of exceptions, of which the example of the Lily just now quoted is one; unless we are with Jussieu to call its single envelope a calyx. There are besides a great many cases in which the rule cannot be at all applied; because the number of stamens does not always correspond to that of the segments of the calyx and petals of the corolla, as may be seen by looking into a flower of the genus *Ranunculus*, or into almost any other flower of the class *Polyandria,* where the stamens are crowded together so as to face both the segments of the one and petals of the other, and consequently to form no mark of distinction in cases of doubt. Alternation with the segments of the corolla.

The stamens, though very different in their shape Relation to petals.

---

* Phil. Bot. sect. 90.

and structure from the petals, exhibit however strong indications of being nearly allied to them, and seem in some cases, as in the flower of *Nymphæa alba*, to run mutually into one another, the inner petals being partly stamen, or the outer stamens being partly petals. But in many flowers, particularly the polypetalous, the stamens are entirely convertible into distinct petals, and are often so converted either in part or in whole. In the former case the flower is said to be double; in the latter case it is said to be full. But this singular conversion of stamens into petals is regarded by the phytologist as being altogether an aberration from the laws of vegetable economy, and is found to occur but seldom, except in consequence of culture. The Anemone, *Ranunculus*, and Rose, when cultivated in our gardens, afford examples of the flowers of this description. They are more showy indeed and more generally admired than the flower in its natural state, and are consequently the object of the peculiar care of the florist; but they are regarded by the botanist as being only vegetable monsters.

Division into filaments.

Such is the general character of the stamens considered as individual organs; but from the definition of them that has been already given they are obviously divisible into two distinct parts—the thread-shaped or lower portion, and the bag or *viscus* by which it is surmounted. The former is by botanists denominated the *Filament*, the latter is denominated the *Anther*; of which two parts the anther only is essential to the fructification ; the stamen being capable of performing its functions without a filament, but never without an anther. The consequence is, that many stamens are destitute of the filament altogether, as in the genus *Aristolochia*. But where the filament is present, though the thread-shaped figure is the most general, as in Plantain, yet it is by no means universal. For in some stamens the filament is bristle-shaped, as in *Papaver ;* in some it is flat and spear-shaped, as in *Ornithogalum umbellatum ;* in some it is awl-shaped, as in *Allium oleraceum ;* in some it is club-shaped, that is thickening towards the summit; in some it is petaloid, that is expanding like a petal, as in *Nymphæa alba ;* in some it is wedge-shaped, that is petaloid at the summit but tapering towards the base, as in *Lotus tetragonolobus ;* in some it is heart-shaped, that is petaloid and notched at the summit but tapering towards the base, as in the genus *Mahernia ;* in some it is branched, as in *Carolinea princeps ;* in some it is jointed, as in genus *Salvia ;* in some it is cuspidated, that is having the summit divided into several stiff joints, as in Sand Garlick ; and in some it is without an anther, as in *Gratiolus.*

In its direction it is upright, as in *Sambucus Ebulus ;* or expanding, as in *Ranunculus ;* or inflected, as in the labiate flowers ; or reflected, as in *Urtica pilulifera ;* or spiral, as in the genus *Hirtella.*

In most flowers the filaments are distinct and detached from one another, as in the Primrose; but sometimes they are united into one, two, or more sets. If they are united into one set, as in the Mallow, the flower is said to be *Monadelphous;* if they are united into two sets, as in the Pea, the flower is said to be *Diadelphous;* and if they are divided into several sets, as in St. John's-wort, the flower is said to be *Polyadelphous.*

In most stamens the surface of the filament is smooth, as in *Anthericum serotinum;* but in some it is pubescent, as in *Orobanche elatior;* in some it is villose, as in *Narthecium ossifragum;* and in some it is bearded, that is partially covered with hairs, as in *Tulipa sylvestris.*

The colour of the filament is generally white, as in the *Convolvulus;* but in the Peach-tree it is spotted, and in the Medlar-tree it is red. In some stamens the filaments are elastic, that is unbending themselves with a considerable force as the corolla expands, as in the genus *Urtica;* and in some they are susceptible to the action of stimuli, as in those of the Barberry, which if touched with the point of a needle or other fine instrument on the inner side and near the base, will spring forward immediately with a sudden jerk to the centre of the flower.* Such are some of the most remarkable of the peculiarities of the filament or lower part of the stamen.

And anther.

The anther or summit, and only essential part of the stamen, is a small bag or vessel containing a fine powder, which when ripe bursts its integuments and explodes. In the stamens of most flowers there is an individual anther attached to each individual filament, as in the stamens of the Grasses; but in the stamens of the flowers of the genus *Mercurialis,* there are two anthers to a filament, which are hence said to be didymous; in *Fumaria* there are three anthers to a filament; in *Theobroma* there are five; and in *Bryonia* there are five anthers to three filaments. In their attachment they are generally fixed to the upper extremity of the filament, in which case they are said to be terminal, as in the Tulip-tree; or they are fixed to the one side of the filament, in which case they are said to be lateral, as in the Herb Paris; or they are altogether without filaments, and then they are said to be sessile, as in the genus *Aristolochia.* The direction of the anther is vertical, that is parallel to the axis of the flower, as in the Tulip; or oblique, that is forming an oblique angle with the axis, as in the Honey-suckle; or incumbent, that is attached to the summit of the filament by the middle, and resting upon it horizontally, as in the Pink; or versatile, that is incumbent, but turning as if upon a pivot so as to be put in motion by the gentlest agitation of the air, as in the Grasses. If the anthers are situated so as to approach each other, as in the Cyclamen, they are said to be convergent; if they are connected together by the viscidity or pubescence of their surface, as in *Utricularia,* they are said to be adherent;

---

* Smith's Tracts.

and if they are united together so as to form a tube, as in the florets of the Dandelion, they are said to be *Syngenesious.*

The figure of the anther is linear, as in *Magnolia;* oblong, as in the *Sedum*; oval, as in *Fuschia;* globular, as in the Lime-tree; kidney-shaped, as in Fox-glove; peltate, as in the Yew-tree; forked, as in the Grasses; arrow-shaped, as in the Crocus; or horned, that is terminating in two long awns, as in the Heaths. The size of the anthers is estimated by comparison with that of the filaments, considered as being longer, shorter, or of the same length. The surface is smooth, as in the Grasses; or pubescent, as in *Acanthus;* or bearded, as in *Verbascum*; or beset with glandular particles, as in *Leonurus;* or furnished with longitudinal angles or furrows, as in the Rose and Ash. The structure of the anther is unilocular, that is consisting of one cell, as in Mercury; or bilocular, that is consisting of two cells, as in the *Orchis;* or tetralocular, that is consisting of four cells, a case that occurs but rarely, as in *Tetratheca.** In the *Contortæ* and a few of the *Orchideæ* the anthers are solid.

Which contains the pollen. But where the anthers consist of cells, as in most cases, they contain also a fine powder, which botanists denominate the pollen, and which at the period of the maturity of the flower bursts its integuments and explodes, the integuments assuming soon after a shrunk and withered appearance. In some plants the pollen explodes with considerable force, the cells bursting open as if by an elastic spring, and dispersing it by their own spontaneous action. In the Cypress-tree it is thrown out with such force and in such abundance as to resemble a cloud of smoke; and if the flowers of the Birch or Willow are suddenly shaken when the pollen is ripe, they will exhibit a similar phenomenon. The aperture by which the pollen is discharged is sometimes a small pore opening near the summit, as in the Heaths; but generally it is a longitudinal slit, as in the Lily; and is always effected in some definite or determinate manner in the same species.

---

* Smith's Introduction, p. 271.

Its varieties.

The colour of the pollen is very generally white; but sometimes it is yellow or orange, and sometimes it is glaucous or violet. When examined under the microscope the individual particles are found to assume a great variety of forms in different flowers. They are often globular, oval, or cylindrical. But in the Violet they are angular; in the *Narcissus* they are kidney-shaped; in the *Geranium* they are perforated; and in the *Orchis* they are conglomerated into masses. The surface of the globules is generally smooth; sometimes it is net-like; sometimes it is wrinkled; and sometimes it is beset with prickles, as in *Malva* and *Helianthus annuus.*

Appearance under the microscope.

But the individual particles of the pollen are themselves organized substances; as may be seen also with the assistance of a good microscope, each particle consisting of a thin and membranous bag, capable of resisting the action of the air, but extremely susceptible to the action of moisture, which as soon as it meets with, it explodes, like the anther itself, discharging a fine and subtile vapour, or a sort of fluid in which there are contained globules still smaller. The discharge of the primitive globules may be seen by placing an anther of the *Equisetum* upon a bit of paper, and watching it till it bursts; when it will often afford a very curious and singular spectacle; the globules after having made their escape seeming to be still in agitation, attracting and repelling one another, and rebounding as if endowed with a peculiar irritability. The discharge of the secondary globules is discoverable particularly in the pollen of the Valerian; and the experiment is best made by placing the anthers on water.*

Parts.

Gærtner describes the globules of pollen as consisting of the following parts:—1st, An external cuticle, sometimes smooth, and sometimes set with hairs. 2dly, A cellular substance. 3dly, A parenchyma contained in the cells, and seemingly a rude and unorganized mass of granular matter. The globules, if put into water, swell and burst; first the cuticle, then the interior cells, and then the parenchyma, exploding and emitting a subtile and elastic vapour, or sort of fovilla which swims on the surface. But this phenomenon does not take place in oil.

---

* Phys. des Arbres, Liv. iii. chap. I.

Hedwig describes the globules of pollen as consisting of only one vascular membrane filled with a gelatinous fluid, but without any cellular substance interspersed. The globule explodes instantaneously when placed in warm water.

Koelreuter describes each globule as consisting of two distinct membranes, an outer and an inner membrane, containing a cellular mass, from which a thin oily and inflammable fluid slowly exudes when placed in water, forming a shining and conspicuous pellicle that floats on the surface.

It is plain that the above descriptions have been taken from the pollen of different species of plants; as they are too much at variance with one another to agree to the same species; but from the known accuracy of the observers it is to be believed they are respectively correct. The sudden explosion of the globules is the more common phenomenon. But there may also be some globules that exhibit the phenomenon described by Koelreuter. For in the *Contortæ* and some of the *Orchideæ* the anthers are altogether a solid and homogeneous mass, and do not burst open like anthers in general, but gradually extricate an oily and inflammable fluid, as it is elaborated within them.*

---

* Gært. Introd.

SUBSECTION IV.

Definition. *The Pistil.*—The pistil is a small and column-shaped but often pestle-shaped substance (whence probably the name), occupying almost invariably the centre of the flower, and encompassed immediately by the stamens. (*Pl.* IV. *Fig.* 11.) This is at least the case in all hermaphrodite plants, by which are meant all plants producing both stamens and pistils in the same flower, as may be exemplified in that of the Lily, in which an individual pistil, occupying the centre, is surrounded by six stamens. But it often happens that the stamens and pistils are not produced in the same flower, but each in a different flower; and of this there are three cases. 1st. When the stamens and pistils are produced in different flowers on the same plant, in which case the plant is said to be *Monœcious;* the flower containing stamens only being the barren flower, and the flower containing pistils only being the fertile flower. 2dly. When the stamens and pistils are produced in different flowers, and on different plants, in which case the plants are said to be *Diœcious;* the plant bearing flowers with stamens only being barren, and the plant bearing flowers with pistils only being fertile. And 3dly. When hermaphrodite flowers, and flowers producing stamens and pistils separately, are found on the same plant, in which case the plant is said to be *Polygamous*.

Number. Sometimes the pistil is single or solitary, that is if the flower produces but one, as in the Cherry; and sometimes it is multiplicate, that is when the flower produces more than one, as in the Apple and Pear. In the former case the flower is said to be monogynous; in the latter it is said to be digynous, trigynous, or polygynous, according to the number of pistils.

Magnitude. The magnitude of the pistil is estimated by comparison with that of the stamen. It is said to be long, if longer than the stamens; and short, if shorter than the stamens. If it rises above the corolla it is said to be salient; if it is contained within the corolla it is said to be enclosed. Its position, as has been already observed, is almost universally central with regard to the other parts of the flower, as in the Tulip; but there are a few cases of exception in which it is not so; and in which it is said to be eccentric, as in Monk's-hood, but more particularly in *Monœcious* and *Diœcious* plants.

In polygynous flowers the pistils are said to be crowded, that is growing in clusters, as in *Dryas*; or divergent, that is expanding at the summit, as in the Herb Paris; or reflected, as in the Grasses; or capitate, that is forming a globular bunch, as in the Plane-tree.

Parts. The individual pistil, like the individual stamen, consists of at least two, but very generally of three distinct parts, the ovary, the style, and stigma, or summit.

The Ovary.

The ovary is the lower extremity of the pistil, supporting the style and stigma; and containing the rudiments of the future seed. Linnæus gave it the name of the germe or germen.* But as the term germen seems to denote rather the embryo itself, than the substance in which it is contained, I think the term ovary is entitled to the preference, denoting, as it does, merely the integument or receptacle of the embryo, the idea meant to be expressed. But there is also another reason for the preference here given, owing to that application of the term germe, or germen, by which it has been already made to signify a bulb, or bud.

Its situation as superior or inferior.

If the ovary is situated immediately upon the base or receptacle of the flower, as in *Arbutus*, it is said to be sessile; if it is supported upon a pedicle elevating it above the base of the flower, as in the Poppy, it is said to be stipitate; if it is situated below the insertion of the calyx, as in the Rose and Apple, it is said to be inferior; if it is situated above the insertion of the calyx and enclosed within it, it is said to be superior, as in the Primrose; and if it is situated partly above and partly below the insertion of the calyx, it is said to be semi-superior, as in *Saxifraga nivalis*. In the genus *Adoxa* it is inferior with regard to the corolla, and half inferior with regard to the calyx. These distinctions were introduced by Linnæus, and are at present pretty generally adopted. Gærtner has besides remarked* that the modification of the superior ovary is by far the most common, as well as perhaps the most natural, being seemingly the best adapted to the protection of the tender germe, as for example, in the Grasses, the Labiate or *Verticillatæ*, and *Leguminous* plants. He adds that the inferior ovary, which is exemplified in the *Umbelliferous* and *Cucurbitaceous* tribes, is not very frequent, and that the intermediate ovary, which is examplified in some of the *Saxifragæ* is still less so, being doubtful whether compound flowers belong to the former or the latter. According to this view of the subject there is sometimes considerable difficulty in ascertaining to which of the three foregoing modifications the flower belongs.

---

* Phil. Bot. Sect. 102.

Adherent or detached.

But according to M. Ventenat, who has no doubt examined the subject with due attention, the ovary is always superior; and when it is thought to be inferior or semi-inferior, it is only because the lower part of the calyx is so intimately incorporated with the ovary as to appear to be part of it, as in the case of the Apple and Medlar,† the skin of which is thus considered as part of the calyx. Instead therefore of the terms inferior, superior, and semi-superior, M. Ventenat proposes to substitute the terms adherent, semi-adherent, and detached. The ovary is adherent if it is closely invested by the lower part of the calyx, and surmounted only by the border, as in Enchanter's Night-shade. It is semi-adherent, if it is invested only in part by the calyx, as in some species of Saxifrage. And it is detached, if it is included in the calyx, but not adhering to it, as in the Primrose.

---

* De Seminibus. Introd.

† Tab. du Reg. Veget.

If this view of the subject is correct, the terms superior, and semi-superior, are consequently absurd, and ought to be given up: but there seems to be at least some room for doubt with regard to the universality of the fact alleged by M. Ventenat as the ground of the introduction of the new terms which he substitutes in the place of the old; for however well his remark may apply in the case of the Apple and Medlar, in which the part usually called the calyx is persistent, yet I do not see how it can be made to apply in cases in which the part usually called the calyx is deciduous, as in the Willow-herbs; because the very circumstance of the falling of that part points out to us, at least by analogy, the line of circumscription bounding a distinct organ, and the connecting link that forms the bond of union between the calyx and ovary. And if not, then we may just as well say that the corolla is also always inferior; or that the leaves themselves are merely a continuation of the bark, and not distinct organs.

Its figure.

The figure of the ovary is roundish, as in the Cherry; or egg-shaped, as in the Pink; or oblong, as in Goat's-beard; or prism-shaped, as in Wall-flower; or turbinated, as in Fescue-grass; or compressed, as in the Vetch. In its structure it is simple, as in the Apple and Pear; or double, as in Galium; or divided into four, as in Labiate flowers. It consists also of one cell, as in the Hazel; or of two, as in Wall-flowers; or of several, as in the Spurge and Beech. The surface is generally smooth or slightly pubescent; but sometimes it is set with rough hairs, as in *Caucalis nodosa;* and sometimes with glands, as in *Cheiranthus.*

The style.

The style which is the middle portion of the pistil, is a prolongation of the substance of the ovary, issuing generally from its upper extremity, but sometimes also from the side or base; and terminating for the most part in the stigma. If it issues from the upper extremity of the ovary, as in the Tulip, it is said to be terminal; if from the side, as in the Rose, it is said to be lateral; and if from the base, as in the Strawberry, it is said to be basiliar. It is not however altogether essential to the formation of a perfect flower, and is consequently often wanting, as in the Poppy; though the ovary and stigma never are. But when pre-

Sometimes wanting.

HALLIDIE LIBRARY OF THE UNIVERSITY

sent it is either simple, as in the *Convolvulus,* in which there is but a single style to an ovary; or multiplicate, as in the Grasses, in which there are two styles to an ovary. In such cases the ovary is said to be monostylous, distylous, or polystylous, according to the number of styles which it supports.

Its figure and structure.

The figure of the style is thread-shaped, as in *Oxalis;* or cylindrical, as in *Monotropa;* or awl-shaped, as in *Lychnis;* or club-shaped, as in Snow-flake; or triangular, as in *Pisum;* or conical, as in *Lecythis.* Compared with the stamens it is either thicker, as in Snow-flake: or not so thick, as in *Sedum;* or of the same thickness, as in *Lamium.*

In its structure it is either simple and without divisions, as in *Atropa*; or cleft at the top, as in *Clethra;* or divided, that is, cleft down to the middle, as in *Galium;* or dichotomous, that is, having the primary divisions again sub-divided into two, as in *Caturus.* In its direction it is upright, as in *Solanum Nicotiana;* or bending in the form of a curve, as in the *Labiate flowers;* or ascending from a horizontal to a vertical position, as in *Papilionaceous flowers;* or twisted or inflected, as in the Pink; or reflected, as in the Grasses.

Like the ovary the style is also smooth, as in *Hypericum;* or pubescent, as in *Althæa,* or hairy or glandular. If it falls when the ovary is converted into fruit, it is said to be deciduous, as in the cherry; and if it remains attached to the ripened ovary, an appendage of the fruit, it is said to be permanent, as in the Star of Bethlem.

The stigma. The stigma is a small and glandular-looking substance crowning the style, and hence also denominated the summit. This is at least its general character, in which case it is said to be terminal. But it happens sometimes, though rarely, to be situated upon the side of the ovary, as in the genus *Scheuchzeria;* in which case it is said to be lateral; and where the style is altogether wanting, as in the genus *Nymphæa,* it is then said to be sessile, being situated immediately upon the ovary. If there is but one stigma to a pistil, it is said to be single, as in the Tulip; if two, it is said to be double, as in the Grasses; if three, it is said to be triplicate, as in the Iris; and if many it is said to be multiplicate, as in the Mallow.

Its figure. The figure of the stigma is globular, as in *Hottonia palustris;* hemispherical, as in the Berberry; conical, as in *Utricularia;* truncated, as in *Asphodelus;* oblong, as in *Holcus;* club-shaped, as in *Quinquina;* petaloid, as in the Iris; peltate, as in *Nymphæa;* radiate, as in the Poppy; cruciform, as in *Penæa;* awl-shaped, as in the Hazel-tree; thread-shaped, as in *Eriocaulon;* pencil-shaped, as in *Milium;* triangular, as in *Convallaria;* hollowed, as in *Vinca;* folded, as in *Podophyllum;* or feathered, as in the Grasses in general.

Direction. The direction of the stigma is upright, that is, parallel to the axis of the flower, as in *Aquilegia;* or oblique, that is, forming an angle with the axis of the flower, as in the Herb Christopher, and Violet; or flexuose, that is, forming several regular and contrary curves in the same plant; or twisted, that is, forming several irregular curves in different planes; or inflected, that is, bent towards the centre of the flower, as in *Lotus;* or reflected, that is, bent from the centre, as in the Oak; or convolute, that is, rolled up spirally in a direction towards the centre, as in the Crocus; or revolute, that is, rolled up in a direction deflected from the centre, as in the Dandelion; or pendant, as in *Orobanche.*

Structure. In its structure the stigma is either simple, that is, without divisions, as in the Snow-drop; or cleft into two or more divisions, as in *Mentha* and *Epilobium;* or lobed, as in the Tulip; or appendicled, as in Vinca; or two-lipped, as in *Pinguicula.* The surface of the stigma is sometimes smooth, as in the Artichoke; but very generally pubescent, as in *Aira;* or it is bearded, as in *Vicia;* or hispid, as in *Althæa;* or wrinkled, as in *Hesperis;* or channelled, as in *Colchicum;* or jagged, as in *Rumex.* At the time of the maturity of the flowers it is moist, exuding a sort of viscous fluid. In its substance it is glandular or fleshy, as in the Lily; or petalous, as in the Iris; or membranaceous, as in the Berberry. In its duration it is deciduous, that is, perishing with the stamens and corolla, as in plants in general; or persistent, and crowning the fruit, as in the Poppy and Wall-flower.

SECTION II.

The Flower-stalk.

THE flower-stalk is a partial trunk or stem, supporting one or more flowers, if the flowers are not sessile, and issuing from the root, stem, branch, or petiole, and sometimes even from the leaf. It is considered by botanists as comprehending two different species, the scape and peduncle. Species.

SUBSECTION I.

The Scape.—The scape, is a flower-stalk issuing immediately from the root, and forming the only trunk of the plant. It may be very happily exemplified in the different species of *Primula.* (*Pl.* IV. *Fig.* 1.) In *Primula vulgaris,* in which several scapes issue from the same root, each is a slender and cylindrical stalk, simple and undivided in its structure, and supporting a single flower. In *Primula veris,* in which one scape only issues from the root, it is a stalk of greater thickness and strength, branched or divided at the top, and supporting several flowers. In this case the lower portion, issuing from the root, is called the common foot-stalk; the branches are called pedicles. Definition.

The scape is for the most part naked, that is without any leaf-like appendages issuing from its surface, as in the Hyacinth; or scaly, that is, furnished with scale-like appendages, as in *Tussilago Farfara;* or leafy, as in Sweet Flag. In *Valisneria spiralis* it is spiral; and in the *Cyclamen* it becomes spiral about the time of the maturity of the flower. In *Convallaria majalis* it is semi-cylindrical, and in *Galanthus nivalis* it is two-edged.

SUBSECTION II.

Definition.

The Peduncle.—The peduncle is a flower-stalk issuing from any part of the plant except the root, and not constituting the only trunk. If it issues from the main stem, as in *Averrhoa Bilimbi,* it is said to be caulinary; if from the main branches, as in *Averrhoa Carambola,*[*] it is said to be rameal; if from the leaf stalk, as in *Turnera ulmifolia,* it is said to be petiolar; and if from the leaf, as in *Ruscus,* it is said to be foliary. If it issues from the angle formed by the leaf or branch, and stem, it is axillary, as in *Convolvulus* and *Ruppia maritima;* if from the extremity of the branch or stem, it is terminal, as in *Ranunculus bulbosus.* It is characterized also from the circumstance of having its insertion opposite to the leaf, as in *Hydrocotyle inundata;* or between the leaves which is a case of rare occurrence, as in *Solanum indicum*. It is solitary, as in *Anagallis;* or in pairs, as in *Azalea procumbens;* or clustered, as in *Verbascum nigrum*.

---

[*] Smith's Introduction, 130.

Direction. In its direction it is laid close to the stem or branch, as in *Physalis pruinosa;* or erect, as in *Hieracium umbellatum;* or expanding, as in *Chelidonium majus;* or nodding, as in *Helianthus annuus*.

Figure. In its figure it is for the most part cylindrical, as in *Tragopogon pratensis;* or tapering, as in *Lapsana;* or thickening towards the top, as in *Tragopogon porrifolius;* or triangular, as in *Scirpus triquetur;* or quadrangular, as in *Convolvulus arvensis;* or jointed, as in *Pelargonium*.

In its structure it is simple, supporting but one flower, as in *Geranium sanguineum*; or divided into branches, each supporting a flower, as in *Erodium maritimum;* in which case the lower part is called the common peduncle, the divisions being called pedicles.

Proportion. It is said to be short, if shorter than the leaf, as in *Prunus insititia;* and long, if longer than the leaf, as in *Vicia sylvatica*. It is smooth, as in *Convolvulus;* or pubescent, as in *Trifolium filiforme;* or scaly, as in *Senecio vulgaris*.

SECTION III.

The Receptacle.

Definition.

The receptacle is the seat of the flower and point of union between the different parts of the flower, or between the flower and the plant, whether immediate and sessile, or mediate and supported upon a flower-stalk. Some botanists have considered it as a part of the flower itself, though this view of the subject is not entirely correct; but it is at any rate a part of the fructification, and cannot possibly be wanting in the case of any flower whatever. Like the flower-stalk it has been discriminated by botanists into two different species which are not indeed disignated by proper names, but characterized by the appellations of the proper receptacle, and the common receptacle.

SUBSECTION I.

Exemplified.

The Proper Receptacle.—The proper receptacle is a receptacle proper to an individual flower, though seldom so conspicuous as to attract any particular notice on account of the small space which it occupies. Let any flower with its flower-stalk be taken and stripped first of the calyx, then of the corolla, then of the stamens, and then of the pistil or pistils, and the receptacle will appear, seldom indeed exhibiting any thing like a distinct or definite figure, except in cases in which the flower is furnished with a great many stamens or pistils, requiring a considerable extent of base. This may be exemplified in the Poppy, *Ranunculus*, or Water Lily.

Blended with the calyx.

But there are many cases in which the receptacle cannot be exhibited as constituting altogether a distinct and separate organ, being often so intimately blended with the calyx as to render it difficult to ascertain the limits by which the one is to be distinguished from the other. This is particularly the case in flowers of which the calyx is persistent, as in *Convolvulus* and *Rubus;* in which the external surface of the calyx is obviously a continuation of the outer rind of the flower-stalk, and the inner surface apparently a continuation of the receptacle, which is contained in the hollow of the calyx and identified with its substance.

And hence consituting the perigynous insertion of Jussieu.

This difficulty of discrimination has given rise to some diversity of opinion among botanists upon the subject of the calyx and receptacle, one regarding as part of the former what another regards as part of the latter. The stamens of the class *Icosandria* and of many other plants were regarded by Linnæus as inserted in the calyx, and so they have been regarded by most of his followers, as well as by the celebrated Jussieu in the distribution of his natural orders, who founds one of his primary and principal divisions on what he denominates the perigynous insertion of the stamens or corolla.

Which is denied by Salisbury.

But the fact of the perigynous insertion has been lately called in question by Mr. Salisbury,* and subjected to the fiery ordeal of his keen and rigorous investigation; from which he thinks himself entitled to conclude that no such thing exists as an insertion of the stamens or corolla in the calyx, and that no instance of it can be produced throughout the whole extent of the vegetable kingdom—thus denouncing and exploding the doctrine entirely; and demolishing with one stroke of his rough but dexterous hand the whole superstructure of the perigynous orders of Jussieu, as well as the primary principle of the class *Icosandria* of Linnæus.

Mr. Salisbury admits, however, that his observations were hastily committed to paper, and so the reader of them will most probably think. He displays, indeed, a very extensive acquaintance with plants, as was to be expected from a botanist of so much experience; and gives ample proof of his talent for acute and accurate discrimination. But his observations are upon the whole of much less importance than he seems to imagine; because the insertion in question will still remain perigynous, whether it be regarded as originating in the calyx or receptacle; so that the whole of his long paper is but little better than cavil respecting terms, of which he himself so loudly complains.

It is of great importance, no doubt, to discriminate all such parts and organs of the plant as are really distinct in nature. But if there are cases in which nature has not marked out the boundaries of the different organs by some specific trait, man will search for them in vain. It must be admitted, indeed, that there are many genera in which the corolla and stamens are inserted in a sort of fleshy substance lining the hollow of the calyx, which to them is no doubt a receptacle. But it is at the same time obvious that this substance is incorporated into the calyx, or united with it, so as that the two form but one body. If, therefore, we call it a receptacle we must admit that it partakes also of the character of a calyx; and if we call it a calyx we must admit that it partakes also of the character of a receptacle.

---

* Lin. Trans. vol. viii.

This can be nowhere better exemplified than in the genus *Pyrus* or *Rubus,* in which the intimate union of the receptacle and calyx is obvious even in the mature state of the ovary, the calyx being still permanently attached to the shrunk receptacle, from which indeed it cannot be separated except by force.

But substantiated by facts.

But in the flower of the genus *Rosa,* to which Mr. Salisbury so loudly appeals, there is certainly some room for doubt with regard to the accuracy of the description by which the corolla or stamens are said to be inserted into the calyx; because in flowers of this genus the segments, at least of what is usually called the calyx, are deciduous, which deciduity seems to point out to us the natural line of distinction between the calyx and receptacle, as in other cases in which the calyx is deciduous. But this, as has been already observed, will not affect their perigynous insertion. If it is allowed however to be a fair criterion for judging of the boundary separating the calyx and receptacle, we may readily ascertain the fact of the insertion of the corolla and stamens in the calyx, by ascertaining whether they are in any case inserted in a calyx which is deciduous. Now this is rendered evident from the inspection of a single flower of any species of *Epilobium,* the corolla and stamens of which are separately inserted in the base of a deciduous calyx, or deciduous portion of a calyx, with which they fall. The result, therefore, of this long discussion is, that the fact of the perigynous insertion of Jussieu is fully substantiated by the production of examples of the unequivocal insertion of the corolla and stamens in an acknowledged calyx, and that if Mr. Salisbury's view of the subject were even admitted to be the true one, still the insertion would be equally perigynous.

If it is yet said that the part in which the corolla and the stamens are inserted cannot be a calyx but a receptacle—I answer that this is merely a quibble about words. If they are inserted in the calyx, to them it is no doubt a real receptacle; but with regard to the flower in general it is still a real calyx. In the same manner as a calyx is sometimes to be found fitted for performing also the functions of a corolla, and participating of its character. And there are cases in which a single envelope occurs in all the three capacities at once of calyx, corolla, and the receptacle of the stamens, as in the genus *Polygonum;* in which Mr. Salisbury, indeed, maintains that the stamens are not at all inserted in the involurum, that is the single envelope; though it is plain, upon the slightest inspection, that they are incorporated with it by the whole extent of their lower half, from which they cannot be detached but by force.

From this it follows that the receptacle of the corolla and stamens is not always the same with the receptacle of the pistil or ovary, as may be also rendered evident by the inspection of a flower of the genus *Epilobium* or *Agrimonia.* In the former the ovary is inferior, the calyx being inserted upon its summit, and the corolla and stamens upon the base of the calyx, which is deciduous. In the latter the ovary is superior with regard to the calyx, being inserted in the bottom of the cup, or if you will, in the receptacle which lines the bottom of it, and incorporated into its substance; and the corolla and stamens being inserted in a fleshy and glandular sort of receptacle originating in the inner surface of the calyx at a point superior to the ovary, and closing the mouth of the calyx, but perforated by the styles.

Hence it follows also that the receptacle sometimes constitutes a part of the flower, and sometimes not. If it forms a part of the calyx, or is contained within the calyx, as in *Rubus* and *Agrimonia,* it constitutes a part of the flower; but if it is distinct from the calyx, and the calyx only inserted in it and finally deciduous, as in the genus *Ranunculus*, it does not constitute a part of the flower.

In either case it assumes some considerable variety of figure. In the genus *Rubus*, in which the receptacle of the corolla and stamens is the fleshy substance lining the surface of the calyx, the receptacle of the pistils is a conical prolongation of the same substance, issuing from the bottom of the cup and occupying the centre of the flower. In *Geum* it is an oblong substance originating in the same manner and beset with fine hairs. In *Potentilla* it is a dry and juiceless knob; and in *Fragaria* it is a soft and pulpy substance, of a globular figure, resembling a berry. In the *Ranunculus* the receptacle of the whole flower is a flat and glandular-looking disk; in *Clematis* it is a small knob; and in *Adonis* it is a sort of oblong spike.

SUBSECTION II.

Exemplified in compound flowers.

The Common Receptacle.—The common receptacle (*Pl.* IV. *Fig.* 12.) is a receptacle common to many flowers, and consequently larger and more conspicuous than the proper receptacle. It has accordingly been more attentively examined by botanists and more minutely described. It is peculiarly conspicuous in compound or *syngenesious* flowers, as well as peculiarly important to their generic discrimination. If a flower of this description is taken and stripped of its individual florets, the common receptacle will be laid bare. In *Helianthus annuus* it is a large, flat, and fleshy disk; in the Artichoke it is concave; in *Tanacetum* it is convex; in *Bellis* it is conical; and in *Leontondon* it is globular. Its surface is naked, as in *Pyrethrum;* or hairy, as in *Carduus;* or bristly, as in Knapweed; or chaffy, as in *Carlina;* or warty, as in *Gnaphalium gallicum;* or dotted, as in the Dandelion; or flawed with little cavities resembling the cells of a honey-comb, as in *Onopordum.*

And others.

But there are many plants which have their flowers placed upon a common receptacle, though not syngenesious or compound; such as the Willow, the Grasses, the Fig, and *Arum.* In the Willow the common receptacle is thread-shaped; in the Grasses it is linear, but flexuose; in the Fig it is the pear-shaped substance usually denominated the fruit; and in the *Arum* it is the club-shaped column issuing from the bosom of the spathe.

SECTION IV.

The Inflorescence.

Definition of the term.

THE inflorescence, a term introduced by Linnæus, is the peculiar mode of aggregation in which flowers are arranged or distributed upon the plant, whence it is called sometimes also the mode of flowering.

If the flowers are solitary or in pairs they are regarded merely as being caulinary or rameal, axillary or terminal, according to the distinctions instituted in treating of the peduncle. But when many grow together their aggregation forms a feature in the habit of the plant peculiarly striking and peculiarly interesting to the botanist, as forming the most elegant and most invariable of all specific distinctions, as well as being of undoubted importance in Varieties. determining genera. On this account the inflorescence claims our particular notice, and may be regarded as consisting of the several following varieties: the head, the whirl, the spike, the panicle, the thyrse, the cluster, the corymb, the fascicle, the umbel, the cyme, the catkin, the spadix.

SUBSECTION I.

Description and modifications.

The Head.—The head is a group or assemblage of flowers distributed upon the extremity of the stem or branch, or upon a general peduncle as their common axis, upon which they are aggregated into a globular form. The inflorescence of *Statice Armeria* affords a very good example of a head of flowers. (*Pl.* V. *Fig.* 1.) But though the head is always somewhat globular, it is not by any means strictly so; for in *Trifolium filiforme* it is hemipherical; in *Trifolium montanum* it is conical; and in *Dipsacus fullonum* it is oval. The individual flowers are either sessile, as in *Trifolium suffocatum;* or pedicled, as in *Thymus Serpyllum.*

The head is also either sessile, as in *Trifolium glomeratum;* or supported upon a peduncle, as in *Trifolium ochroleucum;* or it is axillary, as in *Trifolium scabrum;* or terminal, as in *Gomphrena globosa.* Sometimes it is interspersed with a number of small leaves, as in *Thymus Serpyllum;* at other times it is naked, that is without leaves, as in *Trifolium.*

SUBSECTION II.

Description and modifications.

The Whirl.—The whirl (*Pl.* V. *Fig.* 2.) is a group or assemblage of flowers surrounding the stem or branch as a common axis, and in the form of a ring. The *Verticillate flowers* of Tournefort, or *Labiate flowers* of Linnæus, afford the best examples. If the individual flowers composing the whirl are sessile, as in *Marubium,* the whirl is said to be sessile; and if they are pedicled, as in *Thymus Calamintha,* the whirl is said to be pedicled. But sometimes the whirl extends only half way round the stem; and in this case it is said to be dimidiate, as in *Melissa officinalis.* Plants affecting this mode of inflorescence produce generally a succession of whirls, which are arranged at regular intervals upon the upper part of the stem or branch. In some plants the whirls stand close to one another, the intervals between them being very small, as in the *Mentha acutifolia;* in others they stand wide apart, as in the lower whirls of *Mentha viridis.* In some they are interspersed with a number of small leaves, as in *Ajuga reptans;* and in others they are naked or without leaves. The number of individual flowers composing the whirl is different in different species, varying from six or eight, to ten or more, in which case the whirl is said to be many-flowered, as *Leonurus.*

SUBSECTION III.

Description and modifications.

The Spike.—The spike (*Pl.* V. *Fig.* 3.) is an assemblage of flowers arranged in close succession upon a common and longitudinal axis, which is a vertical prolongation of the stem, or on a common peduncle, which is generally erect. The term seems to have been originally confined to an assemblage of sessile flowers arranged in the foregoing order, as in the ear of Wheat or Barley; but it is now extended by the common consent of botanists, to such also as are supported on short pedicles, if otherwise corresponding to the definition, as in common Lavender; and even to such as are arranged in whirls, particularly if the whirls are closely crowded together, as in some of the Mints. A spike generally begins flowering at the base, as in *Lythrum Salicaria*, and continues to protrude its blossoms in gradual succession up to the top; so that the lower flowers are oftentimes quite decayed before the upper ones have begun to expand. But in *Sanguisorba officinalis* the flowering begins at the top, and descends in a reversed order gradually to the base.

Terminal or lateral.

The spike is terminal, as in *Agrimonia;* or axillary and lateral, as in *Veronica officinalis.* It is said to be crowded if the flowers are set close together, as in *Orchis maculata;* and interrupted if the intervals between them are considerable, as in the whirls of *Mentha rotundifolia.* In its figure it is either linear, as in *Rotbollia;* or cylindrical, as in *Phleum pratense;* or elliptical, as in *Phalaris canariensis;* or jointed, as in *Salicornia herbacea;* or distichous, that is having the flowers arranged in two opposite rows, as in *Lolium pratense.* But sometimes the two rows are turned about to one side, as in *Dactylis stricta* and Ladies' Traces, and then the spike is said to be unilateral.

Simple or compound.

The spike is simple and without divisions, as in *Verbena officinalis;* or compound and subdivided, as in *Lavendula pinnata.* In the Grasses the divisions of the spike are denominated spikelets, which consist of one, two, three, or many flowers, as in *Poa fluitans.* The spike is also often leafy, as in *Ajuga reptans* and the Mints; but it is more frequently naked or without leaves, as in the Grasses. If two spikes issue from the same stalk and in the same horizontal plane, they are said to be conjugate, as in *Verbena officinalis;* and if several issue from the same stalk and in the same horizontal plane, they are said to be bundled.

In the Grasses the common axis of the spike is somewhat peculiar in its structure, and designated by a proper name—the *Rachis*, which is linear and upright, as in Barley; or flexuose, as in Darnel; or angular, as in Cock's-foot; or jointed, as in Wheat; or alternately furrowed, as in *Rotbollia*.

SUBSECTION IV.

Description and modifications.

The Panicle.—The panicle is an assemblage of flowers supported upon a primary and terminal peduncle or axis, that is irregularly divided into secondary peduncles, which are sometimes again subdivided into ternary peduncles. It is exemplified in *Bromus arvensis* and *Avena flavescens*, and may be regarded as resembling a sort of loose spike. It is loose and spreading, as in *Saxifraga umbrosa*; or close and compact, as in *Poa rigida*; or straddling and divaricate, as in *Prenanthes muralis*. It is said to be simple if the primary peduncle is furnished only with secondary peduncles, as in *Bromus erectus*; and compound if the secondary peduncles are furnished also with ternary peduncles, as in *Dactylis glomerata*. The spikelets are either sessile, as in *Poa procumbens*; or pedicled, as in *Poa nemoralis*. (*Pl.* V. *Fig.* 4.) They are also either erect, as in *Bromus erectus*; or nodding, as in *Bromus asper*; or turned to the one side, as in *Festuca rubra*.

SUBSECTION V.

Description and modificatons.

The Thyrse.—The thyrse (*Pl.* V. *Fig.* 5.) or bunch is an assemblage of flowers supported upon a primary peduncle, subdivided as in the branching panicle; but differing from it in having the lower or partial peduncles longer, and placed in a horizontal or expanding direction; and the upper ones shorter and erect. From this peculiarity of structure it assumes for the most part a sort of oval figure, and may be exemplified in *Tussilago Petasites* or common Butter-bur. It is terminal, as in *Syringa vulgaris;* or lateral, as in the Vine; naked, as in the preceding examples; or interspersed with leaves, as in the Privet.

SUBSECTION VI.

Description and modifications.

The Cluster.—The cluster (*Pl.* V. *Fig.* 6.) is an assemblage of flowers supported upon partial pedicles that are attached to a common foot-stalk, either primary or secondary, which is generally pendant. It bears a considerable resemblance both to the spike and panicle, though looser than the former and more compact than the latter. If the pedicles are immediately attached to a primary and undivided peduncle, as in the Currant, the cluster is said to be simple; but if they are attached to secondary peduncles, as in *Solanum Dulcamara,* it is then said to be compound. It is terminal, as in *Actea spicata;* or lateral, as in the Currant; pendant, as in *Cytisus Laburnum;* or erect, as in *Pyrola minor.*

Supposed to include the Grape.

The inflorescence of the Vine was regarded and described by Linnæus as being a cluster, and consequently arranged under this head. But Dr. Smith has now transferred it to the thyrse because its ultimate ramifications are sometimes obscurely umbellate, a character inconsistent, as he thinks, with the cluster, but not so with the thyrse. Whatever may be the value of this observation, the inflorescence of the Vine comes evidently much nearer to the thyrse, in its general habit, than to the cluster, and seems to be arranged with more propriety under the former than under the latter.

SUBSECTION VII.

Description and modifications.

The Corymb.—The corymb (*Pl.* V. *Fig.* 7.) is an assemblage of flowers supported upon peduncles issuing from a common axis, as in the spike, but having the peduncles so proportioned in length as to be of an equal height, and the flowers consequently so placed as to be nearly on a level. The inflorescence of *Spiræa opulifolia*, a shrub common in our gardens, affords a good example of the corymb, which is said to be simple if the peduncles are simple, as in *Arabis Turrita;* and compound if the peduncles are divided, as in *Iberis amara.*

SUBSECTION VIII.

Description and modifications.

The Fascicle.—The fascicle (*Pl.* V. *Fig.* 8.) is an assemblage of flowers arranged precisely as in the corymb, except, perhaps, somewhat more orderly, and differing from it merely in having its peduncles more crowded and condensed, so as to form a sort of compact bundle. It is exemplified in *Dianthus barbatus* or Sweet Williams, in which the peduncles are regularly decussated. But in erecting the fascicle into a species separate from the corymb, botanists seem to have instituted a distinction without a warrantable difference.

SUBSECTION IX.

Description.

The Umbel.—The umbel (*Pl.* V. *Fig.* 9.) is a mode of flowering in which a number of flower-stalks issuing from a common centre diverge like the rays of an umbrella, bearing their flowers on the summit and raising them about the same height. The Carrot, Parsnep, and Hemlock, are familiar examples, which with all other plants affecting this mode of inflorescence are denominated umbelliferous or umbellate.

Modifications.

If the rays of the umbel are undivided so that each individual ray supports but a single flower, as in the genus *Hydrocotyle*, the umbel is said to be simple. But if the rays of the primary umbel are themselves subdivided so as to form and support secondary umbels, as in the genus *Heracleum* and most umbellate plants, the umbel is then said to be compound. It is terminal, as in the Carrot; or lateral, as in *Caucalis nodiflora.* It is also sessile, that is without any foot-stalk, as in *Sium nodiflorum;* or pedunculate, that is furnished with a proper foot-stalk, as in *Tordylium officinale.* The rays are said to be crowded if placed close together, as in *Sanicula europea;* or distant if placed wide apart, as in *Sium repens.* The flowers are either equal, as in *Bunium;* or unequal, as in *Heracleum.* The surface of the umbel is flat, as in *Imperatoria;* or concave, as in the Carrot; or convex and approaching to globular, as in *Angelica sylvestris.*

SUBSECTION X.

Description and modifications.

The Cyme.—The cyme or tuft (*Pl.* V. *Fig.* 10.) consists of an assemblage of flowers supported upon peduncles issuing from a common centre, as in the umbel, and rising to the same height; but irregularly divided at the top. The inflorescence of the Elder is a very familiar example. In *Sedum Aizoon* the cyme is sessile; in *Viburnum* it is supported on a foot-stalk. In the Elder it is terminal; in *Laurustinus* it is often lateral; in *Sedum sexangulare* it is leafy; in *Sedum anglicum* it is naked.

SUBSECTION XI.

The Catkin.—The catkin (*Pl.* V. *Fig.* 11.) is a mode of inflorescence consisting of an assemblage of flowers generally incomplete, whose calyx is a small scale-like substance attaching them to a common and elongated receptacle, as in a close and condensed spike. It is exemplified in the very familiar cases of the groups of barren flowers produced by the Hazel and Walnut. The catkin was indeed considered by Linnæus as being altogether a species of calyx, and accordingly arranged as such. But this arrangement is obviously incorrect, unless stamens and pistils are to be considered as forming parts of the calyx, which cannot be the case; because stamens or pistils always form part of the catkin. Dr. Smith, however, still arranges the catkin under the head of calyx, and yet when he comes to describe it he calls it "an aggregate flower,"* which entirely overthrows the notion of its being a calyx, and even contradicts his own arrangement. I am not aware of any good reason why the catkin should not be regarded as a peculiar mode of inflorescence, as botanists for the most part do now regard it. For it is no objection to this view of the subject to say, that the scale-like calyx adheres so firmly to the common receptacle as to seem a part of it; because there are, in all modes of inflores-

Description.

Incorrectly regarded as being a calyx.

---

* Smith's Introduction, p. 284.

cence, examples of flowers with a persistent calyx that falls only with the peduncle; and in the catkin there are examples of scales that are deciduous, as in *Betula alba.*

Its figure.

The figure of the catkin is sometimes globular, as in the Cypress, and sometimes oval, as in the Hop; but it is more frequently cylindrical, as in the Willow and Poplar. In *Betula nana* it is lateral and erect; in the Hazel it is terminal and pendulous. In *Salix Croweana* it is sessile; in *Betula alba* it is pedunculate. If the scales are smooth the catkin is smooth, as in *Salix amygdalina;* but if pubescent or rough with hairs, as in *Salix nigricans,* so also is the catkin.

SUBSECTION XII.

Description.

The Spadix.—The spadix (*Pl.* V. *Fig.* 12.) is a species of inflorescence consisting of an assemblage of flowers which, like those of the catkin, are generally incomplete; but which are supported upon a common and vertical foot-stalk, that is invested with a leaf-like sheath from the base of which it issues. The term was originally adopted by Linnæus, and applied to denote merely the general receptacle of the flowers of the Palms; but as it forms also evidently a distinct species of inflorescence it ought unquestionably to be arranged as such; because the inflorescence includes the receptacle, but the receptacle does not include the inflorescence.

Modifications. The spadix is simple, that is without divisions, as in the different species of *Arum ;* or branched, as in the Palms. The foot-stalk is linear, as in *Zostera marina ;* or cylindrical, or flattened, or club-chaped, as in *Arum.* In *Arum* the flowers encircle the foot-stalk about the middle ; in *Calla* they invest it wholly ; and in the Palms they form with the several divisions of the foot-stalk terminal or lateral spikes.

SECTION V

The Fruit.

Definition. In the progress of fructification, when the several organs of the flower have discharged their respective functions, the petals, the stamens, the style, and often the calyx, wither and fall. The ovary alone remains attached to the plant, and swells and expands till it reaches maturity. It is now denominated the fruit. But at the period of its complete developement it also detaches itself from the plant and drops into the bosom of the earth, containing and protecting the embryo of the future vegetable. The fruit then is the ripened ovary and the parts which it contains. In popular language the term is confined chiefly to such fruits as are esculent, as the Apple, the Peach, and the Cherry, or perhaps, to the esculent part only ; but with the botanist the matured ovary of every flower with the parts contained constitutes the fruit.

The best and most accurate description of fruits and their several parts, as well as the most scientific distribution into their several species which has yet been made, is that of Gærtner in his very elaborate work *De Fructibus et Seminibus Plantarum,* which shall consequently be our principal guide on this interesting and intricate subject.

As the fruit consists of the ripened ovary, it follows that the situation and distribution of the fruit must be the same with that of the flower which has preceded it. If the flower was radical or caulinary, so is the fruit; if it was lateral, axillary, or terminating, so is the fruit; if it was sessile or pedunculate, spiked or verticillate, so also is the fruit. And for the same reason if the ovary was adherent the fruit must be adherent; and if the ovary was detached the fruit must also be detached. Or, to express these modifications in language perhaps more correct, if the flower was inferior the fruit will be inferior; if the flower was superior the fruit will be superior; and if the flower was intermediate the fruit will be intermediate. It does not follow, however, that mere modifications of position shall be the same; because it frequently happens that of plants of which the flower has been drooping the fruit is erect, as in the Lily and Cowslip; and on the contrary, that of plants of which the flower has been erect the fruit is drooping, as in Wheat and Barley.

Figure. The figure of the fruit assumes almost as much variety as that of the flower; but the following are its most frequent modifications: it is either spherical, as in the Cherry; or eliptical, as in the Almond; or oblong, as in the Coffee-tree; or cylindrical, as in *Epilobium;* or inversely conical, as in the Pear; or inversely heart-shaped, as in *Veronica;* or kidney-shaped, as in *Anacardium;* or three cornered, as in the Tulip; or twisted, as in *Medicago sativa;* or jointed, as in *Hedysarum;* or inflated, as in *Staphylea;* or winged, as in Crown Imperial; or stellate, as in the Poppy. The apex is described also as being acute, as in *Sago;* or obtuse, as in the Filbert; or truncated, or emarginate, as in *Thlaspi;* or umbilicate, as in the Apple.

Size. The size of the fruit is also very various, but is not always proportioned to the plant that produces it. The Oak and the Ash though among the largest of trees, produce a fruit that is comparatively but very diminutive; while the Gourd, whose stem is but herbaceous and creeping, produces a fruit of a most enormous bulk. The largest fruits occur among the palms, or among the *Cucurbitaceous* and *Leguminous* plants. The fruit of *Leontarus maldivica* is often a foot and a half in diameter; and that of *Mimosa scandens* often six feet in length.

Contexture. The fruit in its immature state is always soft and pulpy, but in its matured and ripened state it is generally firm and compact, and sometimes so very hard that it can scarcely be cut. In the

Cherry it is succulent, in the Strawberry it is pulpy, in the Apple it is fleshy, in *Staphyllea* it is membranaceous, in the Elm-tree it is leathery, and in the Nut it is woody. But it is very seldom of the same consistence throughout. For sometimes the outer part is soft and the inner part hard, as in the Peach and Cherry; and sometimes the outer part is hard and the inner part soft, as in the Filbert and Cocoa-nut; but sometimes both parts are alike, as in the Pine Apple. From these different modifications Gærtner institutes a division of fruits into soft, hard, and mixed.* The Currant is an example of the first; the Filbert of the second; and the Peach or Apricot of the third.

Covered or naked.

Some fruits are covered with a thick rind; many with a thin cuticle only; and many are without even that. The cuticle may be seen in succulent berries; and the rind or bark in the Orange and Cocoa-nut. The bark is in general closely attached to the interior part; but sometimes it is remote from it and inflated, as in *Scytalia chinensis*. In its exterior surface it is generally smooth and uniform, as in the Cherry; or cottony, as in Peony; or scaly, as in Sago; or dotted, as in the Orange; or perforated with holes, as in *Artocarpus;* or ribbed, as in the Melon; or rough, as in *Galium aparine;* or set with tubercles, as in *Onobrychus;* or with prickles, as in *Canna indica;* or with thorns, as in *Trapa*. But it is often also exquisitely coloured. When the blossom begins to fade, and the colours of the corolla to decay, the beauty of the plant seems to have departed with the departing flower. But the beauties of the departing flower are often more than compensated in the rich and mellow colouring of the fruit. The ripened tints of autumn are found to be equally pleasing with the bloom of spring, and the colours of the Peach and Apricot, the Plum and Cherry, are in nothing inferior to the blossom that preceded them. Coloured.

---

* Gært. De Seminibus.

If a single flower produces only a single seed, or several seeds contained in a single seed-vessel, the fruit is said to be single; but when it produces many seeds, whether detached or united, except by one style, the fruit is then said to be multiplicate. But the number of the fruit produced by an individual flower is not always the same even in the same species; because all the original ovaries are not always impregnated. If the fruit is produced in pairs, as in umbelliferous plants; or in threes, as in the Lily; or in fours, as in the Verticillate plants; or in fives, as in the Geranium; or in an indefinite number from the same flower, as in the Rose and Ranunculus; it is then said to be conjugate, or compound. Single.

The conjugate or compound fruit is either lobed or divisible. It is divisible if in its immature state it presents a uniform and integral appearance, but afterwards separates into distinct portions, as in Conjugate.

the pod of the Pea and Bean. It is lobed if the portions into which it may separate are attached to a common axis, as in *Colchicum.* There is also another species of compound fruit distinguished by Gærtner, which is formed by the union of two or more ovaries of different flowers combined into one whole, as in *Caprifolius* and *Artocarpus.* I do not recollect whether Gærtner has designated this species of fruit by any particular name; but it might be very appropriately designated by the appellation of the combined fruit.

Such are the general and external modifications of the fruit considered as forming an individual whole. But it is yet to be considered as composed of constituent parts,—an exterior part, which is the ripened ovary, now the Pericarp; and an interior part, which is the Seed.

SUBSECTION I.

Definition.

The Pericarp.—The pericarp which is merely the exterior part of the ripened fruit, and which generally constitutes its principal mass, assumes by consequence the same exterior modifications of form, at least as long as it remains entire. But in the mature state of the fruit the pericarp often separates spontaneously into several distinct sections or portions, called valves, including the seed; and in some cases also an upright and central column, called the axis of the fruit or pericarp, as in

Divisible into valves.

the Pink. All pericarps do not open in the same manner; but all individuals of the same species open in the same manner; and the pericarp is said to be one-valved, two-valved, three-valved, or many-valved, according to the number of valves into which it opens.

The form and contexture of the valves is as much diversified as the form and contexture of the fruit. But the external surface is generally convex, and marked with a longitudinal furrow; and the internal surface generally concave. The margin is simple or inflected, forming often a prominent seam which connects the valves. But sometimes the valves are connected by means of an additional substance inserted between them. In the Lily it is a fine membrane resembling a net, in the Tulip it is rough and bristly.

The aperture by which the valves open spontaneously is generally longitudinal, extending in many cases from the top to the bottom of the pericarp, as in *Galanthus;* but in other cases extending only half way down, as in *Chrysosplenium*, and forming semi-valves; and in others extending for a space so very short that the pericarp is only said to be toothed, as in *Primula.* But sometimes also the aperture is transverse or horizontal, as in *Centunculus*, *Hedysarum,* and *Anagallis.* In most plants, as in *Pyrola*, the valves open externally; but in *Colchicum* they open internally; and in *Triglochin* the opening is from the base upwards.

Simple, and containing one cavity; or

Sometimes the several valves, when united, form only one cavity, as in *Anagallis;* and sometimes they form several cavities, as in the Iris. In the former case the pericarp is said to be simple; in the latter, it is said to be compound.

Compound, and divided by partitions.

The compound pericarp is divided into internal cavities by means of a number of thin and membranaceous substances, called partitions, intersecting the interior of the fruit, and attached sometimes to the axis, and sometimes to the valves. In the former case they are said to be central; in the latter parietal. But sometimes also they are attached both to the axis and the valves, and then they are said to be copulative. If they form an enclosed cavity they are said to be complete, as in *Oxalis;* but if they do not form an enclosed cavity they are said to be incomplete, as in the Poppy. Sometimes they are attached longitudinally to the middle of the valves, in which case they are said to be ventral; and sometimes they are formed of the inflections of the edges of the valves, in which case they are said to be marginal, and are always double.* Sometimes they are placed opposite to the valves, as in *Epilobium;* and sometimes perpendicular to them, as in *Hedysarum.* They are also described as being vertical or horizontal, parallel or contrary, with a reference to the position of the valves.

---

* Gært. De Sem. Introd.

The cavities formed by the union of the valves and partitions, and in which the seeds are lodged, are denominated cells. In some fruits their figure is distinct and well defined; but in others, although the seeds are separated, yet there are no regular cells, the seeds being imbedded in a sort of pulp, as in the Grape and Gooseberry. Of those whose figure is distinct and well defined, some contain one seed and others more. In some fruits the cells are close and compact, but in others they are remote and distended, as in *Staphylea.* The number of cells is not always constant even in the same species, but is liable to the same accidental defects as the number of ovaries. In their position they are opposite, as in *Veronica;* or verticillate, as in the Tulip and Heaths; or longitudinal, as in the Bean; or irregular, as in *Cyamus Nelumbo.*

Which form cells enclosing the seeds.

If a pericarp of one cell contains only one seed, it is said to be monospermous; if it contains two seeds, it is dispermous; and if many seeds, polyspermous. If the pericarp contains more than one cell, still the individual cell is characterized from the number of seeds.

That part of the fruit or pericarp to which the seeds are attached is denominated the receptacle of the seed. Sometimes the valves are the receptacle, as in *Butomus umbellatus;* sometimes the partitions are the receptacle, as in the Tulip and Poppy; sometimes the base of the pericarp, as in *Borago;* sometimes the apex, as in the Elm; and

Which are attached to a receptacle.

sometimes the margin, as in the Pea. In the Pink the receptacle is the central column, and in compound flowers the receptacle of the florets is also the receptacle of the seeds, exhibiting the same variety of form and surface.

By the spontaneous separation of the valves of the simple pericarp, and by the spontaneous separation of the valves, or consequent opening of the partitions of the compound pericarp, the contained seeds are disengaged, or extricated. But all pericarps do not open by means of valves, even though they should contain several distinct cells; for the seeds are often extricated merely by means of one or more pores opening in the pericarp, and forming a passage for their discharge. Sometimes the pores are situated in the apex of the pericarp, as in *Antirrhinum Orontium;* sometimes in the sides, as in *Campanula;* and sometimes in the base, as in *Lycopsis.*

If no opening is effected in either of the foregoing modes, the fruit falls to the ground when mature with the contained seed, which finally bursts the pericarp in the process of germination, and thus extricates itself.

Naked seeds.

Such are the general characteristics of the pericarp, where a pericarp is present. But there are some seeds, such as those of the labiate flowers, which are altogether destitute of a pericarp, and hence said to be naked. Gærtner, however, who for depth and accuracy of research stands altogether unrivalled, on the subject of fruits and seeds, and whose authority is consequently great, seems inclined to regard all seeds whatever as furnished with a pericarp,* not excepting even those that are generally called naked, in which the cuticle of the seed is the pericarp. But the question ought not to be whether a cuticle is in any case to be regarded as a pericarp, but whether or not all seeds are furnished with a pericarp distinct from their own proper integuments. The cuticle is no doubt a covering, but it is not a pericarp; and the seed that has no other covering is with propriety denominated naked, in the same manner as the Indian is said to be naked, because he is without clothes, although he is still covered with his own proper skin.

Of pericarps however, that are conspicuous and undisputed, botanists generally enumerate the following species :—The Capsule, the Pome, the Berry, the Nutshell, the Drupe, the Silique, the Legume, the Cone; of which in their order.

Definition and varieties.

ARTICLE 1. *The Capsule.*—The capsule (*Pl.* VI. *Fig.* 1.) is a dry and membranaceous pericarp separating for the most part, when ripe, into valves, or, at least, opening in some definite and determinate manner. It may be exemplified in the Snowdrop and Bell-flower. It is one-valved, as in *Primula*; two-valved, as in *Circæa;* many-valved, as in *Oxalis;* or without valves, as in *Fraxinus.*

---

* Gært. De Fruct. et Sem. Plant. vol. i. Introd.

In the Lily the valves are vertical; in *Anagallis* they are transverse; in *Colchicum* they are introflected. It is one-celled, as in *Viola;* two-celled, as in *Veronica;* three-celled, as in *Iris;* or many-celled, as in *Andromeda.* In *Convolvulus* the partitions are central; in the Poppy they are marginal and incomplete; in the Tulip they are perpendicular to the valves; and in *Nymphæa* they bear the seeds. In the Iris the opening is longitudinal; in *Hyoscyamos* it is horizontal; in *Silene* it is at the apex; in *Phyteuma* at the side; and in *Triglochin* at the base.

In some cases the varieties of form or structure which the capsule assumes are so striking or peculiar, as to have been thought worthy of being designated by proper names. Gærtner* enumerates and describes the four following: the Utricle, the *Samara,* the *Bag,* the *Coccus.*

The utricle.

The utricle is a small and bladder-like capsule without valves, consisting of one cell and one seed. Gærtner exemplifies it in *Chenopodium* and *Clematis,* in which Dr. Smith seems to regard it as being merely a cuticle.† But there are, at any rate, other plants in which we must regard it as being something more. In *Galium* and most other cases it is said to be tight, that is, closely investing the seed; but in *Adonis* and *Thalictrum,* it is said to be loose, that is, not closely investing the seed. In *Amaranthus* it bursts horizontally in the middle, and in *Chenopodium* it is so tender as to be easily rubbed off with the finger.

---

* Gært. De Sem. Introd.

† Smith's Introd. p. 279.

The samara. The samara is a compressed and leathery capsule, of one or two cells, but without valves, terminating in a membranaceous wing or border, and falling off entire with the contained seed, by which it is irregularly burst open in the process of germination, as exemplified in the Ash, Elm, and Maple. Dr. Smith, however, suggests an objection to the use of this term as denoting a variety of the capsule, on the ground of its having been preoccupied by Linnæus, and appropriated to the designation of a genus.

The bag. The bag is an elongated and leathery capsule consisting of one valve and one cell, and opening longitudinally on the one side. It is sometimes single but more frequently duplicate, with the seeds loose, or attached to a proper receptacle which is generally the edge of the seam by which it opens. It may be exemplified in the genus *Vinca* or *Pæonia*.

The coccus. The coccus is a dry and elastic capsule of two or more lobes joined together, each forming a cell, and containing a seed; but separating when ripe from the axis, and bursting longitudinally into two valves united at the base. It is two-celled, as in *Mercurialis*; three-celled, as in *Euphorbia*; or many-celled, as in *Hura crepitans*; the valves of which, as we are told, when fully ripe and dry, frequently burst open with a sudden and violent jerk so as to produce an explosion like the report of a pistol.

Article 2. *The Pome.*—The pome (*Pl.* V. *Fig.* 2.) is a pulpy or fleshy pericarp without valves, but enclosing a capsule. It is exemplified in the familiar case of the Apple, from the Latin appellation, for which it has taken its name. It is generally of a globular or oval figure, as in most varieties of Apple; but sometimes it is inversely conical, as in many varieties of Pear. At the apex it is marked with a small cavity surrounded by the remains of the calyx, which is persistent, or in the language of Ventenat, adherent, which cavity is by botanists denominated the *umbilicus,* and by gardeners, the eye of the fruit. At the base there is often also a small cavity formed by the expansion of the pome around the insertion of the foot-stalk, which is not, I believe, designated by any proper name; but in the Pear the pome tapers down gradually to the point of insertion, and renders the cavity less distinct. The enclosed capsule is a thin and membranaceous substance, consisting for the most part of five distinct cells.

Definition and modifications.

Article 3. *The Berry.*—The berry (*Pl.* VI. *Fig.* 3.) is a soft and pulpy pericarp containing one or more seeds, but not separating into regular valves, nor enclosing a capsule. It is exemplified in the very familiar case of the Currant and Gooseberry. It is not however always strictly succulent; for in the Ivy it is of a dry and mealy contexture, and in *Trientalis* it is covered with a sort of brittle crust. The same may be said of the Gourd, Melon, and Cucumber, together with the Lemon and Orange, which, though regarded by botanists as being varieties of the berry, are yet covered with a thick coat or rind which is not pulpy. The seed-vessel of *Cucurbitaceous* plants is even distinguished by Gærtner with a proper name, the *Pepo*, and characterized by the peculiarity of having its seeds situated remote from the axis and inserted into the sides of the fruit. The figure of the berry is for the most part globular, as in *Vaccinium*, and the foregoing examples; but in the Strawberry it is oval. In *Daphne* it is one-seeded; in Asparagus it is generally two-seeded; in the Ivy it is three-seeded; and in *Nymphæa* it is many-seeded. Sometimes the seeds are irregularly dispersed in the pulp, as in *Nymphæa;* sometimes they are attached to a common receptacle, as in *Solanum;* and sometimes the cells are separated by regular partitions, as in the Lemon.

Simple or compound.

In the foregoing examples the berry is said to be simple, that is, when it consists of only one ovary; but sometimes it is also said to be compound, that is, when it consists of several ovaries united into one mass, as in the Bramble and Bread-fruit. In this case each ovary contains a seed, and the individual ovaries are also farther designated by the peculiar appellation of *Acini*. It should be observed however that the berry of the bramble is composed of the united ovaries of only a single flower; while that of the Bread-fruit is composed of the united ovaries of many flowers.

Several other fruits, though not corresponding exactly to the above definition or exceptions, are regarded however by botanists as being also varieties of the berry; such particularly as those of the Juniper and Yew-tree. In the former the scales of the fertile catkin, which ultimately become succulent, unite also together and form a globular fruit, resembling a berry so much as to have obtained the name. In the latter the calyx, or receptacle as it is generally believed to be, which is at first a thin and scale-like substance, of a whitish or greenish complexion, embracing merely the base of the ovary, expands and enlarges into a thick and pulpy envelope, of a bell-shaped figure, and of a most beautiful red, investing the whole of the ovary, except at the mouth or open extremity, and giving the fruit the appearance of a berry, as it is generally called; though strictly speaking it is more properly a nut than a berry.

Definition.

Article 4. *The Nut-shell.*—The nut-shell (*Pl.* VI. *Fig.* 4.) is a pericarp of a hard and bony texture, though sometimes crustaceous or leathery, not opening spontaneously, or if opening spontaneously, not into more than two valves. The Filbert and Chesnut are well known examples; the former being an example of the hard and bony shell, and the latter of the soft and leathery. In the genus *Echium* it is crustaceous, and in *Myosotis* it is hard as flint. The figure of the nut-shell is generally roundish or oval; but in the Horn-beam it is angular; and in the Fir it terminates in a membranaceous border called the wing. In the acorn it is one-celled, in *Trapa* it is two-celled, and in the Chesnut six-celled; but the partitions are not perceptible in the mature state of the fruit. The contained seed or nut is generally denominated the Nucleus, and is extricated for the most part by means of a fissure effected in the process of germination; or by the gradual decay of a part. But in the Walnut the shell opens spontaneously into two valves; and in the Filbert, in which it does not perhaps open spontaneously, the valves seem at least to be marked out by a sort of superficial line, and are easily divided with the assistance of a knife. In *Lycopsis* it opens by a hole or fissure at the base, and in *Trapa* by a hole at the apex. Sometimes it is naked, as in *Lycopsis;* but sometimes also it is coated, that is covered with a membranaceous envelope, either wholly or in part, as in the Acorn and Walnut. Figure.

ARTICLE 5. *The Drupe.*—The drupe (*Pl.* VI. *Fig.* 5.) is a soft and pulpy pericarp without valves, but enclosing a nut. It may be exemplified in what is generally called stone fruit, as in the Cherry, the Peach, and Apricot. Its figure is for the most part roundish, as in the Cherry; or eliptical, as in the Apricot. In the genus *Halesia* it Definition.

is winged. Its substance is succulent, as in the Plum; or fibrous, as in the Cocoa-nut; or dry and leathery, as in the Almond, *Sparganium*, and *Gaura*, which last are nearly allied to nuts. It opens for the most part merely by accident or decay; but in the Peach and perhaps a few others, it opens spontaneously.

The shell. The shell of the drupe is generally very hard, whence the appellation of stone fruit. But in some cases it is crustaceous and tender, as in *Styrax callophyllum;* in some it is leathery, as in *Hyphæne;* and in some woody, as in *Cerbera.*[*] It does not perhaps in any case open spontaneously, and yet there are some shells in which the traces of valves may be discovered, as in that of *Elæocarpus;* or in which a division may easily be effected by means of the knife, as in *Prunus.* Incomplete valves, indeed, are sometimes found at the top of the shell, as in *Nitraria* and *Gaura,* so as to make it resemble a toothed capsule;[†] and in a few genera there is an opening formed by means of a hole or pore at the top, as in the Cocoa-nut.

The figure of the shell is very often elliptical, or egg-shaped, but compressed, assuming however a great variety of modifications, sufficient in most cases to determine the species. Its surface is never quite smooth, but often rough and irregularly furrowed, as in the Peach; in order perhaps that it might the more closely unite with the exterior part of the fruit.

---

[*] Gært. De Sem. Introd.

[†] Ibid.

The pyrena.

Sometimes the shell is separable into several different divisions, each forming an enclosed cavity and containing a seed. In this case each division assumes the appellation of a *Pyrena,* and the fruit is said to be dipyrenous, tripyrenous, or polypyrenous, according to the number of divisions into which it separates. The partitions, however, as in the compound nut, are effaced in the matured fruit.

Definition.

ARTICLE 6. *The Silique.*—The silique or pod (*Pl.* VI. *Fig.* 6.) is a dry and elongated pericarp, consisting of two valves with two opposite seams, to which the seeds are alternately attached. It is said to be siliculous if the transverse and longitudinal diameters are equal, or nearly so, as in *Thlaspi;* and siliquose if the longitudinal diameter exceeds the transverse so as to give to the pod an oblong figure, as in *Cheiranthus.* In *Brassica* the pod is cylindrical; in *Erysimum* it is four-cornered; in *Lepidium* it is elliptical; and in *Thlaspi* it is inversely heart-shaped. The surface of the pod is generally smooth or pubescent; but in *Raphanus* and *Sinapis* it is covered with protuberances. Though the valves are generally two, yet the pod of the genus *Bunias* is wholly without valves. In *Dentaria* the valves open with a sudden jerk, and in *Cardamine,* after opening, they roll back spirally. Sometimes the partitions are parallel to the valves, as in *Draba;* and sometimes they are contrary, as in *Subularia*, but always longitudinal. The cells of the silique are generally two, as in *Cheiranthus;* but sometimes the valves are without partitions, and the pod consequently one-celled, as in the genus *Isatis*.

Definition. ARTICLE 7. *The Legúme.*—The legúme (*Pl.* VI. *Fig.* 7.) is a dry and elongated pericarp, consisting of two valves with two opposite seams, to the one of which only the seeds are attached, as exemplified in the Pea and Bean. It consists for the most part of one cell only, as in *Lathyrus;* but sometimes it consists of two cells, as in *Astragalus;* and sometimes of many, as in *Lotus*. It is one-seeded, as in *Trifolium procumbens;* two-seeded, as in *Trifolium fragiferum;* or many-seeded, as in *Pisum*.

Figure. Its figure is oblong, as in *Ulex;* or cylindrical, as in *Orobus;* or compressed, as in *Hippocrepis;* or rhomboidal, as in *Ononis;* or gibbous, as in *Astragalus;* or spiral, as in *Medicago;* or inversely heart-shaped, as in *Polygala*. The substance of the legúme when ripe is membranaceous, as in *Medicago;* or leathery, as in *Vicia;* or firm and woody, as in *Mimosa*. The surface is smooth, as in *Lathyrus Nissolia;* or rough, as in *Lathyrus hirsutus*.

Such is the general character of the legúme; but there is also a peculiar variety of it which, though externally forming longitudinal sutures, to one of which only the seeds are attached, does not yet open longitudinally by means of two general valves; but transversely, by means of joints, each joint forming a cell that contains one seed, which is finally extricated by the opening of the individual joint when detached. This variety of the legúme is regarded by Wildenow as constituting a distinct species of pericarp, designated by the name of *Lomentum.*[*] But it is a distinction to which it seems scarcely entitled.

Definition.

ARTICLE 8. *The Strobile.*—The strobile or cone (*Pl.* VI. *Fig.* 8.) is a tough and woody pericarp consisting of the general receptacle and indurated scales of the catkin. In some cases however, as in *Pinus Larix,* the scales are rather leathery than woody; and in others, as in *Pinus sylvestris,* they are beset with tubercles. Under each scale there is lodged one or more seeds or nuts, in which the seeds are contained. The figure of the strobile is generally conical or cylindrical, as in most species of *Pinus;* but sometimes also it is spherical, as in the Cedar.

In the mature state of the fruit the scales, which are now closely imbricated, cover the seeds or nuts so completely as to assume the appearance of forming only one compact whole, and thus the strobile hangs upon the tree during the whole of the winter season, protecting the enclosed seeds; but the heats of the succeeding summer have no sooner arrived than the scales, formerly close and compact, begin now to shrink and separate, detaching themselves from one another by the whole of their connected surface, and thus forming a passage for the discharge of the seeds.

---

[*] Princ. of Bot. p. 111.

SUBSECTION II.

Definition. *The Seed.*—The seed is the last and most noble part of the fruit contained within the pericarp, and containing the rudiments of a new plant, similar to that from which it has sprung. In the Pea and Bean it is that part of the fruit which is eaten. In the Apple it is that part which is rejected, and lodged within the core.

Figure. The figure of the seed, like that of the fruit and flower, is very much diversified; but it is often globular, as in the Pea; or egg-shaped, as in *Alopecurus;* or oblong, as in *Valerian;* or cylindrical, as in *Pinguicula;* or angular, as in *Cyclamen;* or heart-shaped, as in *Viscum;* or kidney-shaped, as in *Galium;* or crescent-shaped, as in *Hydrocotyle;* or lenticular, as in *Linum;* or acuminate, as in *Herniaria;* or emarginate, as in *Peucedanum.*

Size. The size of the seed is also very much diversified, but Gærtner has established four cardinal sizes, to which the rest may be referred as to a standard.* 1st, The first size includes all seeds exceeding an inch in diameter, whether in length or breadth, as in *Lontarus maldivica,* and the Cocoa-nut: such seeds are of the first magnitude, and are said to be large. 2d, The second size includes all seeds from an inch to two lines in length, that is not larger than the Hazle-nut, nor smaller than Millet-seed: such seeds are said to be of the middle size. 3d, The third size includes all seeds from two lines in length down to half a line, as in the Bell-flower and Poppy-seed: such seeds are said to be small. 4th, The fourth and last size includes all seeds smaller than any of the preceding, as those of the Orchis, which resemble particles of fine dust or powder: such seeds are said to be minute, and are sometimes also said to be scrobiculate, that is, like fine saw-dust.

---

* Gært. De Sem. Introd.

Surface. The surface of the seed is smooth and shining, as in *Linum;* or furrowed, as in *Vinea;* or wrinkled, as in *Dianthus inodorus;* or rough and tubercled, as in *Cynoglossum;* or woolly, as in *Tamarix;* or villose, as in the Rose; or beset with prickles, as in *Caucalis.*

Colour. The colour of the seed seems susceptible of the same modifications of shade with that of the flower and fruit, though it is not in general either so fine or so brilliant, being frequently of a dull red or yellow; or of a rusty or Chesnut hue. But in *Coix* it is of a bright snow-white; in *Pæonia* it is of a deep black or purple; in *Croton cyanospermum* it is of an azure blue; in *Abrus precatorius* it is of a rich scarlet; and in the Kidney Bean it is beautifully variegated.

Position. The direction or position of the seed, with regard to the pericarp containing it, is either upright, that is attached by its own base to the base of the fruit, as in the Grape; or inverted, that is having its base so placed as to face the apex of the fruit, as in the Prune; or horizontal, that is attached by its side and situated at right angles to the base of the fruit, as in Crown Imperial; or pendant, that is suspended from the apex of the fruit or pericarp by a long thread, as in the Ash. (*Pl.* VI. *Fig.* 1.)

Sessile or pedicled.

If the seed is placed immediately upon the placenta or receptacle, as in Bugloss, it is said to be sessile; if it is imbedded in a pulp, as in the Berry, it is said to be nestling; and if it is attached to the receptacle by an intermediate substance it is said to be pedicled, as in the Pea.

The umbilicus.

The substance attaching the seed to the receptacle is generally of a thread-shaped figure, as in the Ash (*Pl.* VI. *Fig.* 1.), and is by botanists denominated the *Umbilicus* or umbilical cord, from its analogy to the umbilicus of animals. Sometimes, however, it is horn-shaped, as in *Acanthus;* or bristle-shaped; or down-like, as in *Epilobium;* and sometimes it is a mere tubercle.

The hilum.

On the surface of the seed and at the point of its attachment to the pericarp, whether mediate or immediate, there is always to befound a mark or scar (*Pl.* VI. *Fig.* 9.), differing in colour and in grain from the rest of the surface. It is the scar left by the natural fracture of the umbilical cord. Linnæus gave it the appellation of the *Hilum,* which it still retains.* Sometimes it is linear, as in *Fraxinella;* sometimes it is oblong, as in the Bean; sometimes it is concave, as in Hellebore; and sometimes it is convex, as in *Euphorbia.* Near to the *Hilum* there is also to be found in some seeds a minute pore or aperture, which however is not always discoverable without the assistance of a glass. But in the garden Bean it is distinctly perceptible to the naked eye; and was by Grew denominated the *foramen.*

The Hilum is regarded by botanists as the base of the seed; and the point opposite as the apex. But Gærtner has instituted also several other distinctions as applicable at least to many seeds, and expedient to their description. Upon this principle Gærtner discriminates in seeds also right and left sides as relative to the foregoing parts, corresponding to the right and left sides of the animal body, as relative to parts analogous.

Number.

The number of seeds produced by a single flower is extremely different in different species. In some plants a flower produces only one seed, as in *Statice* and *Polygonum;* in some it produces two, as in umbelliferous plants; in some three, as in *Euphorbia;* in some four, as in plants with *Labiate flowers;* and in some many, as in *Ranunculus.*

But the great fertility of some peculiar species is altogether astonishing; a single capsule of Tobacco often contains one thousand seeds. A single capsule of *Papaver somniferum,* or the White Poppy, has been known to contain eight thousand;* and a single capsule of the *Vanilla* from ten thousand to fifteen thousand.† A single stalk of *Zea Mays* will produce two thousand seeds;‡ a single plant of *Inula Helenium*, or Elicampane, three thousand; and a single spike of *Typha major*, or Greater Cat's-tail, ten thousand. A single plant of Tobacco has been found by calculation to produce the almost incredible number of three hundred and sixty thousand;|| and a single stalk of Spleen-wort has been thought, by estimation, to produce at least a million of seeds.

---

* Phil. Bot. sect. 86.

CHAPTER IV.

REPRODUCTIVE APPENDAGES.

THE reproductive organs, like the conservative organs, are often found to be furnished with various additional and supernumerary parts, not at all essential to their constitution, because not always present, and hence denominated appendages. Many of them are precisely of the same character with that of the conservative appendages already described, except that they are of a finer and more delicate texture, and demand no particular notice at present.

---

* Grew's Anat. † Barton's Elements.

‡ Lin. Phil. Bot. sect. 132.

|| Hist. Plant. Raiv. lib. i. chap. xii.

Such are the glands, down, pubescence, hairs, thorns or prickles, with one or other of which the parts of the fructification are occasionally furnished. But others are altogether peculiar to the reproductive organs, and are to be regarded as constituting, in the strict acceptation of the term, true reproductive appendages. Some of them are found to be proper to the flower, and others to the fruit; according to which two-fold division I shall now proceed to consider them.

SECTION I.

Appendages of the Flower.

Enumeration.

THE appendages proper to the flower are the involucre, spathe, and bracte, generally designated by the appellation of Floral leaves, as being leaf-like substances situated near the flower, though different in their colour, form, or substance, from the real leaves of the plant; together with the nectary, and several other minute organs presumed to be nectaries, though not certainly known to be so.

SUBSECTION I.

Description.

The Involucre.—The involucre (*Pl.* V. *Fig.* 9.) is a floral leaf or assemblage of floral leaves, peculiar to the tribe of umbelliferous plants, and situated at the base either of the general or partial umbel, or at the base of both. If it is situated at the base of the general umbel, it is a general involucre; and if at the base of the partial umbel, it is a partial involucre. In some species it wholly surrounds the stem or peduncle in a ring or whirl, as in *Daucus;* in others it surrounds it only by the one half, as in *Æthusa.* In the former case it is said to be complete; and in the latter it is said to be dimidiate.

Its figure.

Its figure is generally strap-shaped, if consisting of one leaf; and if consisting of more than one leaf, the individual leaves are so. But sometimes the individual leaves are also egg-shaped acute, as in *Bupleurum;* and sometimes they are bristle-shaped, as in *Cicuta.* The structure of the leaves composing it is either undivided, as in *Caucalis;* or divided into several segments, as in *Daucus,* in which also they are edged with a membranaceous border towards the base, and wing-cleft towards the apex.

If it consists of one leaf it is said to be monophyllous; if of two leaves it is said to be diphyllous; and if of many leaves polyphyllous.

Regarded by Linnæus as a calyx.

Linnæus who adopted and introduced the term involucre, or at least the less harsh and wholly Latin term *involucrum,* at the suggestion, as it appears, of his friend Artedi, regarded the part designated by it as a calyx remote from the flower, and peculiar to the umbel.* Analogy does not however justify this view of the subject, because the flowers of the umbel are not invested by the involucre like the flowers of plants, having confessedly a common calyx; and because they are besides individually furnished with a proper calyx more or less conspicuous, which renders the existence of a common calyx at least dubious, unless it is obviously sanctioned by the evidence of analogy, as in the genera *Dipsacus* and *Scabiosa*.

---

* Phil. Bot. sect. 86.

The involucre is therefore merely a leaf-like appendage of the fructification, and no part of the flower; being regarded as such by Linnæus only because, with Artedi, he believed it impracticable to characterize the different genera of the *Umbelliferæ* without its aid, and was consequently compelled to regard the involucre as a calyx, and the spokes of the umbel as divisions of a branched receptacle, in order that he might apparently not transgress his own fundamental and golden rule of deducing the generic character exclusively from the parts of the flower and fruit; which rule he transgressed in fact without any absolute necessity, the flower and fruit of the *Umbelliferæ* being found sufficently adequate to the purpose of generic discrimination, as well as the flower and fruit of other tribes of plants.*

As Linnæus elevated the involucre of the *Umbelliferæ* to the rank of a common calyx, so M. Mirbel reduces the common calyx of compound flowers to the rank of an involucre.† But in the latter case the reasons hold good for regarding the part in question as a calyx, which in the former case were wanting.

---

* Smith's Introd. p. 311.

† Anat. Veg. tome ii. p. 202.

The aggregate florets of the compound flowers are closely invested by the common calyx, and the individual florets are, at the same time, destitute of a proper calyx unless their down is such. M. Mirbel's supposed improvement therefore is an innovation for which there is no good ground.

SUBSECTION II.

Description.

The Spathe.—The spathe (*Pl.* IV. *Fig.* 8.) is a floral leaf issuing from the upper extremity of the stem or scape, and enveloping one or more flowers by the union or convolution of its edges, which open as the flower expands. The term is restricted by some botanists to such plants only as produce their fructification on a spadix, as the *Arum* and Palms; but by others it is used with greater latitude, being applied also to the sheath which invests the unexpanded flowers of the Narcissus and similar liliaceous plants, in which application of the term there seems to be no impropriety. Linnæus indeed regarded and arranged the spathe as a species of calyx;* but for reasons analogous to those excluding the involucre from the rank of calyx, the spathe is excluded from that rank also.

Modifications.

If it contains but one flower, as in *Narcissus*

---

* Phil. Bot. sect. 86.

poeticus, it is said to be proper; if it contains more than one flower, as in *Narcissus biflorus*, it is said to be general; and if it contains an individual flower, which with itself is included in a general spathe, it is then said to be partial.

It is simple, that is without divisions, as in the *Arum;* or divided into two, as in *Crinum;* or divided into six, as in *Hæmanthus;* or imbricated, that is consisting of a number of scales overlapping each other, as in the Plantain-tree. It is one-valved and opening longitudinally on the one side, as in the *Arum*, in which it assumes, in its state of greatest expansion, a sort of conical figure somewhat cucullate; or it is two-valved, as in *Stratiotes*, in which each valve assumes a sort of concave and boot-shaped figure somewhat compressed. It is leaf-like, as in *Arum maculatum;* or petaloid, as in *Arum Ægyptiacum;* or membranaceous, as in *Galanthus;* or woody, as in the Date-tree. It is deciduous, as in *Allium vineale;* withering, that is fading with the flower, as in *Arum;* or permanent, that is remaining unchanged till the fruit ripens, as in *Stratiotes.*

SUBSECTION III.

Description.

The Bracte.—The bracte is a floral leaf situated on the peduncle or common axis of the fructification, and often so near to the flower as to be mistaken at first sight for its calyx. This is particularly the case in the genus *Nigella* and some species of *Helleborus,* in which however it is known not to be a calyx from the protracted period of its duration, which is equal to that of the other leaves of the plant; whereas the calyx either fades with the flower, or at latest when the fruit has reached maturity. If this observation is extended to other cases of doubt, it will generally lead the inquirer to a correct decision.

But though the bracte is situated for the most part on the stem or peduncle, yet there are cases in which it is situated also on the calyx, as in several species of *Mussænda;** and even on the fruit itself, as in *Mespilus germanica,* in which there is often to be found, besides the floral leaf of the peduncle, an additional floral leaf issuing out of the very body of the fruit, but generally towards the base.

Figure. The figure of the bracte is sometimes that of a calyx, as in *Royena villosa;* or scale, as in *Lonicera nigra;* or thorn, as in *Atractylis cancellata;* or bottle, as in *Ascium coccineum.* But its general form and aspect is that of a leaf, though not always similar to the leaf of the plant. **Colour.** The colour is generally green, as in *Hypoxis erecta*; but it is also often tinged with a variety of different shades. In *Tilia europæa,* which affords at the same time one of the most singular and striking example of the bracte (*Pl.* VI. *Fig.* 10.), it is of a pale yellow; in *Salvia Horminum* it is of a beautiful purple; and in

---

* Smith's Introduction, p. 222.

Bartsia coccinea it is of a bright scarlet, giving it at a distance the appearance of a corolla. In some cases, as in *Melampyrum arvense*, the lower bractes of the spike are green, and the upper ones coloured, passing, as it were, by a regular gradation from the real leaves of the plant to real bractes.

Solitary or in pairs.

The bractes are said to be solitary if there is only one to each flower, as in *Erica Daboecia ;* or duplicate if there are two to a flower, as in *Rosa canina ;* or triplicate if three to a flower, as in *Erica calycina ;* or multiplicate if many to a flower, as in *Bartsia*, in which they are so numerous and so closely crowded together as to form a large tuft or bunch at the end of the stem. In their dimensions they are generally compared with the flower as a standard, and described as being longer, shorter, or of the same length.

The floral leaves of the genus *Euphorbia*, which have generally been regarded as constituting an involucre, because so regarded by Linnæus, Dr. Smith seems inclined to transfer to the head of the bracte, because all species of *Euphorbia* are not umbellate, and because there is no necessity for converting the floral leaves of this genus into a calyx, as there appeared to be in some others, each individual flower being uniformly furnished with a distinct, conspicuous, and proper calyx. This remark is sufficiently to the purpose if the involucre is still to be regarded as a species of calyx. But if it is to be regarded as being merely a floral leaf, which it unquestionably is, it is but of little consequence whether it is called an involucre or a bracte. For the sake of consistency, however, it might be called an involucre when the fructification is umbellate, and a bracte when it is not umbellate.

Confounded with the involucre.

But the floral leaf of the genus *Anemone* has been styled also, by Linnæus, an involucre, and with still less propriety, as exhibiting in no species an umbellate fructification, and having also the floral leaf, at least in one species, *Anemone nemorosa*, so precisely similar to the other leaves of the plant as to be distinguishable only by situation. This therefore, according to Dr. Smith's suggestion, I would transfer to the head of the bracte without the slightest scruple.

SUBSECTION IV.

Definition.

The Nectary.—The nectary (*Pl.* IV. *Fig.* 11.) is an appendage of the flower attached for the most part to the corolla, and secreting or containing a honied juice. It may be exemplified in the horn-like process issuing from the base of the corolla of the Violet or *Orchis*. It assumes however a great variety of shapes and situations in different genera of plants. Sometimes it resembles a tube or cylinder, or slipper, or cowl, or petal, or pore, or gland; sessile, as in Sinapis; or supported upon a pedicle, as in *Parnassia;* and sometimes it is a tuft of hairs, or an assemblage of long and slender threads, or a small and minute scale.

When it is not attached to the corolla it is sometimes placed on the receptacle, as in *Lathræa;* or on the calyx, as in *Monotropa,* if the envelope of that flower is a calyx; or on the stamens, as in the Laurel; or on the anthers, as in *Adenanthera;* or on the pistil, as in *Cheiranthus.*

Observed by Malpighi, Tourneforte, and Vaillant.

This appendage of the flower does not seem to have attracted the notice of the botanists of antiquity, at least as being a secretory organ, or the reservoir of a secreted fluid. The earliest notice I have met with on the subject is that of Malpighi, who in speaking of the leaves of the flowers, that is the petals, admires the singular and curious contrivance of nature in furnishing them with an apparatus which he compares to the cavity of a shell, and in which there is deposited a honey.*

Named by Linnæus.

But as botanists began to be more minute in their investigations, the nectary began also to be more a subject of remark. It was next noticed and described both by Tournefort and Vaillant, at least as it occurs in some peculiar species; but was not yet designated by any proper name which it was perhaps not thought of sufficient importance to merit. But Linnæus, who knew well how to appreciate its real value, as furnishing the botanist with one of the best possible characters of generic discrimination, applied to it the very appropriate name of nectary. And yet no term he has introduced has been more severely censured by contemporary and succeeding botanists, upon the score of its having been made to include a variety of minute parts or organs not certainly known to discharge the functions of which it is descriptive.

---

* Mirabile est quod natura quasi conchas in florum foliis excitavit quibus mel custodiret. Anat. Plant. 47.

The name appropriate.

If it is necessary that a botanical term should always express the use or function of the parts signified, then the term nectary is not indeed quite so appropriate as could be wished, at least as it was used by Linnæus, who applied it unquestionably to a variety of parts or organs of which it cannot be certainly said that they secrete or contain a honied juice. But neither can it be positively said that they do not secrete it. The presumption then from analogy seems still to be in favour of the Linnæan application of the term.

But it is not necessary that a botanical term should always, or perhaps even in any case, be descriptive of the thing signified ; otherwise botanists have sadly misapprehended the object of giving names to plants, and have adopted a nomenclature that is almost altogether founded in error. There cannot therefore be any material inconvenience in using the term nectary as Linnæus did, to signify all such supernumerary appendages of the flower as cannot be reduced to one or other of the foregoing heads.

But as the term nectary professes to be descriptive, and is not in fact always strictly so, the best means of avoiding even the slight inconvenience that may thus exist, at least as far as concerns the object of the present section, is, perhaps, that of regarding the nectary as a generic term, and the different parts or organs included under it as its species, arranged according to the degree of evidence by which they are either known or presumed to be nectarous organs.

Species known to secrete honey.

Of nectaries known to secrete honey the principal species are glands, cavities, and pores. The floral glands of *Cheiranthus*, *Brassica*, *Sinapis*, and many other *Cruciform flowers*, situated within the shorter stamens, are indubitably secretory organs, and the fluid they secrete is nectarous. The cavities observable in the petals of *Ranunculus*, situated immediately above the claw, are also secretory organs, and the fluid secreted is nectarous. The pores observable in the petals of a variety of flowers, as in those of *Hyacinthus orientalis*, are said also to be secretory organs and the secreted fluid often nectarous.* To these may be added the fleshy or scale-like substances which surround the ovary in most plants of the family of the *Proteaceæ*, as characterized by Mr. Brown in his learned and elaborate paper on that natural order.†

Known to contain honey.

Of nectaries known to contain honey the principal species are as follow: The *tube*, being a tubular process issuing from the petal, as in *Helebòrus* and *Pelargonium ;* or the tubular part of a monopetalous corolla, as in *Lamium.* The *spur*, being a spur-shaped process issuing immediately from the corolla, as in *Orchis;* or supported upon a proper pedicle, as in *Aconitum.* The *slipper*, being a petaloid process issuing from the corolla, and inflated in the form of a slipper, as in *Cypripedium.*

---

* Willd. Princip. Bot.

† Trans. of Lin. Soc. vol. x. pt. i.

Presumed nectaries.

Of appendages presumed, from analogy, to be nectaries, but not certainly known to be so, the following species are the most distinguishable. 1. The *vault*, being a small and flattened but somewhat convex process, or several such processes conjoined, originating at the orifice of a monopetalous and tubular corolla, and forming a sort of arch or vault which encloses or covers the stamens, as in common Comfrey and Alkanet. 2. The *beard*, being a tuft of fine hairs or bristles issuing in most cases from the calyx or corolla; but sometimes from other parts of the flower also, as in *Thymus, Iris, Periploca.* 3. The *corollet*, being a petaloid process of one or more pieces surmounting the corolla in the form of a little crown. In *Narcissus* it consists of one piece, which is somewhat bell-shaped, investing the stamens. In *Silene* it consists of several pieces issuing individually from the upper extremity of the claw of each of the petals. 4. *Threads*, being long and slender processes issuing in great numbers from the base or receptacle of the flower, somewhat resembling the filaments of the stamens. In the Passion-flower they issue from the base of the pistil in three concentric circles, and form in their aggregate aspect a triple crown of threads. 5. *Scales*, being minute and often membranaceous substances, of a scale-like appearance, found in the flowers of the Grasses, and distinguishable by their extreme fineness and transparency.

SECTION II.

Appendages of the Fruit.

When not naked.

When the flower with its appendages has fallen, the ovary which is still immature is left attached to the plant, to complete the object of the fructification in the ripening of the contained seed. If it is left without any extraneous or supernumerary appendage, which is a case that often occurs, as in the Cherry, Apricot, and Currant, the fruit is said to be naked. The naked fruit however is not to be confounded with the naked seed, from which it is altogether distinct. For it is the want of a conspicuous pericarp that constitutes the naked seed; but it is the want of an additional integument enveloping the pericarp, that constitutes the naked fruit.

Remnants of the flower.

But all parts of the flower are not always deciduous, and it often happens that one or other of them still continues to accompany the pericarp or seed both in its ripening and ripened state, constituting its appendage, and covering it either wholly or in part, or adhering to it in one shape or other. The appendages of the fruit therefore shall form the subject of the two following subsections.

SUBSECTION I.

Appendages of the Ovary.—In strict propriety of language it has been already seen that the fruit consists merely of the ripened ovary and contained seed. But in a less rigid acceptation of the term, if any part of the flower happens to become persistent and so closely united to the ovary as to seem to form a part of it, it also is included under the notion of the fruit. It is plain however that this is merely by way of accommodation to vulgar opinion, and that the parts in question are but the appendages of the fruit. Thus the indurated scales of the catkin forming the strobile of the Fir, the prickly calyx of the Chesnut, the corolla of the genus *Rumex*, the corolline valves of the Grasses with their awns, the nectary of the *Carices*, and the receptacle of the Strawberry and Fig, though generally regarded as forming part of the fruit, are but in fact appendages of the ovary.

Being the indurated calyx or corolla.

Coating or veiling it.

If the appendage investing the ovary covers it entirely, or so as that the style only perforates the covering, the fruit is said to be coated, as in that of the Hollyhock, which is coated by the calyx; or of the Grasses, coated by the corolla; or of the *Carices*, coated by the nectary; or of the Fig, coated by the receptacle. If the appendage embracing the ovary covers it only partially, the fruit is then said to be veiled, as in that of the Hazel, which is veiled by the calyx; or of the Yew-tree, which is veiled by the receptacle.

The fruit of *Cyamus Nelumbo,* which is also veiled by the receptacle, presents a very curious and singular spectacle in its ripened state; the receptacle, which is of an inversely conical figure with a broad and flat base, being excavated into a number of small and hollow cells, in each of which is lodged a seed or nut protruding by its upper extremity through the orifice of its cell, and thus consequently veiled. But at the period of the maturity of the seed this curious and singular receptacle, laden with fruit, separates from its supporting stalk, and floats down the stream in which it grew; the seeds often germinating, and the young plants shooting as it floats along, giving the whole a slight or fancied resemblance to a *Cornucopia.* And hence, perhaps, the origin of its mythological celebrity, having been regarded among ancient and eastern nations as the emblem of fertility.*

Bloom.

Some ovaries, in other respects naked, are coated with a peculiar sort of substance, called the bloom of the fruit; this is very distinctly observable in most species of Plum, resembling a fine powder sprinkled over the surface of the fruit, and very often tinged with a shade of delicate blue. If viewed through a microscope, while yet attached to the ovary, it gives the surface of the fruit a dotted appearance; but if part of it is scraped off and then put under the microscope, it assumes the appearance of clusters of grains of fine white sand, so that it probably borrows its colour merely from the inner part of the fruit, or from the arrangement of its particles which is now destroyed. It is easily rubbed off with the finger, but it resists the most violent rains, being somewhat of a glutinous consistence, which fits it no doubt both for adhering to the fruit, and for repelling moisture.

---

* Smith's Exot. Bot. No. 7.

In some fruits also, though strictly and literally naked, as in the case of the Apple and Pear, the flower-stalk, ultimately the fruit-stalk, remains attached to the ovary even after it separates from the plant, and forms its appendage. Sometimes the appendage consists of the persistent style, as in *Helleborus* and *Nigella*, in which case the fruit or ovary is said to be beaked; and sometimes it is a wing-like, or crest-like, process issuing from the side or apex, as in *Fraxinus* and *Hedysarum Crista Galli*, in which case the fruit is said to be winged or crested.

SUBSECTION II.

Species. *Appendages of the Seed.*—The appendages of the seed, like the appendages of the ovary, are such supernumerary parts or integuments as are found to accompany or invest it occasionally, either wholly or in part, beyond the usual complement of integuments common to seeds in general, and are consequently not essential to the idea of a seed. The following different species are generally enumerated by botanists: the pellicle, the aril, the down, the tuft, the tail, the beak, the wing.

The pellicle.

The pellicle, or seminal epidermis of Gærtner, is a fine and transparent membrane, investing and concealing the proper surface of the seed, and apparently so identified with its substance, as to be not very easily discovered. It is exemplified in the seeds of *Salvia* and *Convolvulus,* in which last it is said to be covered with a sort of down.* Its adherence to the seed is so complete that it never separates spontaneously from it, but may be detached from it by putting it into water, in which it becomes mucilaginous. The same effect takes place also in the process of germination, as may be seen in the case of the germinating seed of the Fir, or, perhaps, of any other seed furnished with the pellicle in question.

The aril.

The aril is a tunic or coat formed by an expansion of the umbilical cord, and proper to an individual seed, which it invests either wholly or in part, though not adhering to it closely except by the base, and detaching itself at last spontaneously. It is elegantly exemplified in the outer and orange-coloured coat of the seed of *Evonymus europæus,* that presents itself so conspicuously to the eye when the valves of the capsule have opened. In this case it invests the seed wholly, and is hence said to be complete; but in others, as in *Celastrus*, it invests it only in part, and is hence said to be dimidiate; in *Dictamnus Fraxinella*, it is said to invest two seeds. It is generally of a membranaceous or leathery sort of contexture, but in the genus *Evonymus* it is somewhat succulent; and in a few species of *Orchis* it resembles a finely reticulated web. In the genus *Oxalis* it is membranaceous and elastic, ejecting the ripe seed with considerable force.*

---

* Smith's Introduction p. 296.

Of the nutmeg.

The mace which envelopes the pericarp of the nutmeg, so much esteemed for its delicate flavour and relish, is generally regarded by botanists as an aril; and the envelope of the seed of the carex, which Linnæus calls the nectary, is by Dr. Smith transferred to the head of the aril also. But if the foregoing definition is correct, and it includes, as I think, the essential characters of the aril, as defined both by Linnæus † and Gærtner ‡ as well as by Dr. Smith § himself, then it follows that the two above-mentioned organs are improperly denominated arils, as including not only the seed but also the ovary, in which, according to the definition, the aril should be itself contained. The impropriety therefore of including the organs in question under the head of the aril is evident, at least till botanists shall have given more latitude to their definition of the term.

---

* Smith's Introd. p. 297.

† Arillus, tunica propria exterior seminis, sponte secedens. Phil. Bot. sect. 86.

‡ De Seminibus. Introd.

§ Arillus, the tunic, is either a complete or partial covering of a seed fixed to its base only, and more or less loosely or closely enveloping its other parts. Introduction, p. 296.

The down. The down is a fine and hair-like, or plume-like, though sometimes bristly and chaff-like substance, surmounting the seeds of compound flowers. It is either sessile, that is, situated immediately upon the summit of the seed, as in *Hieracium ;* or stipitate, that is, supported upon a pedicle, as in *Lactuca.* In its structure it is either simple, that is, having the individual hairs undivided, as in *Sonchus ;* or branched, that is, having the individual hairs divided, as in *Picris.* In the *Dandelion* and *Tragopogon,* in the former of which it is hair-like, and in the latter feathered, but in both stipitate, it expands horizontally after the decay of the corolla, the individual hairs assuming the appearance of the radii of a circle or spokes of a wheel ; and their aggregate assemblage, as attached to the different seeds, assuming the appearance of a large and globular ball terminating the scape.

The down is generally regarded as being the proper calyx of the individual floret of the compound flower, as well as constituting ultimately an appendage of the seed. And though in all cases its resemblance to a calyx is more fanciful than real, and in most cases altogether dissimilar, yet in several genera, as in *Helianthus, Dipsacus,* and

Scabiosa, it does certainly somewhat approach the character of a calyx, though still chaff-like and membranaceous.

The tuft. The tuft is also a hair-like or plume-like appendage, resembling the down in form and substance, but differing from it in origin and situation. Seeds surmounted with a tuft are always enclosed in a pericarp, as in *Epilobium* and *Asclepias*, which afford good example for illustration; but seeds surmounted with a down have no pericarp.

The tail. The tail is an elongated and feather-like appendage, surmounting, as in the case of the down and tuft, the apex of the seed, but formed of the persistent style. It is exemplified in the seeds of *Clematis* (*Pl.* VI. *Fig.* 12) and *Anemone Pulsatilla,* in the former of which it is twenty times longer than the seed.

The beak. The beak is an elongated appendage, formed also of the persistent style, but not feathered. It is exemplified in the genus *Scandix* and *Œnanthe,* and several other of the *Umbelliferæ.*

The wing. The wing is a broad and membranaceous appendage issuing from the side or apex of the seed, but sometimes also surrounding the margin. It is either solitary, as in *Swietenia;* or in pairs, as in *Thapsia;* or in threes, as in *Moringa;* or in fours, as in Buck-wheat. If it is attached to the margin it is entire, as in *Allamanda;* or emarginate, as in *Syringa;* or boat-shaped, as in Marigold; or blistered, as in *Cynoglossum omphalodes.*

Miscellaneous appendages.

There are also several other appendages that occasionally accompany the flower, fruit or seed, less conspicuous perhaps, but not less worthy the attention of the botanist, as furnishing him with characters equally subservient to the purposes of generic or specific discrimination, at least when used with discretion.* Such is the pubescence of the flower or fruit, and fine and wool-like hairs which sometimes invest or attach to the seeds, as in the case of *Eriophorum* and *Scirpus*, and which are different in their origin and situation both from the down and tuft, such as the prickles arming the seeds of the genera *Caucalis* and *Daucus*, and the gland-like substance situated near the scar of some seeds, as in the genera *Ulex* and *Spartium*.

---

* Lin. Trans. vol. x. p. 25.

PART II.

IMPERFECT PLANTS.

Called also cryptogamous plants.

IMPERFECT plants are plants defective, or apparently defective, in one or other of the more conspicuous parts or organs, whether conservative or reproductive, belonging to vegetables in general; such as the root, stem, leaf, blossom. Linnæus characterized them by the appellation of cryptogamous plants, because their organs of fructification are not yet detected, or are so very minute as to require the aid of the microscope to render them visible. To this circumstance, perhaps, as well as to the apparent insignificance of many of them in the scale of vegetable being, we are to attribute the reluctance with which botanists seem to have entered upon the study of them, and the great obscurity that still envelopes the subject. Not that the subject has been left altogether neglected; but that it presents unusual difficulties, retarding indeed the progress of inquiry, but enhancing the merit of the sedulous inquirer; as may be exemplified in the case of Dillenius, Michelli, Bulliard, and above all, in that of the illustrious Hedwig (born, as it has been said, to abolish cryptogamy), each of whom acquired his celebrity from the depth or accuracy of his investigation in this obscure and difficult department of botany.

Divisible into tribes or families.

As in the perfect plants, so in the imperfect plants, the eye readily recognizes traces of a similitude or dissimilitude of external habit and deportment characterizing the different individuals of which they consist, and suggesting also the idea of distinct tribes or families. And upon this principle different botanists have instituted different divisions, more or less extensive, according to their own peculiar views of the subject. But one of the most generally adopted divisions of imperfect plants is that by which they are distributed into *Ferns, Mosses, Hepaticæ, Algæ, Fungi;* according to which several heads I shall now institute my description of their external structure.

CHAPTER I.

FERNS.

Description and habitats.

FERNS are herbaceous, and for the most part stemless plants, dying down to the ground in the winter, but furnished with a perennial root from which there annually issues a frond bearing the fructification. The favourite habitats of many of them are heaths and uncultivated grounds intermixed with Furze and Brambles; but the habitats of such as are the most luxuriant in their growth, are moist and fertile spots, in shady and retired situations, as on mossy dripping rocks, or by fountains and rills of water.* Some of them will thrive even on the dry and barren rock, or in the chinks and fissures of walls; and others, only in wet and marshy situations where they are half immersed in water.

SECTION I.

Conservative Organs.

Modifications.

The Root.—The root of the family of the Ferns, as most other natural families, assumes very different aspects in different species. In *Osmunda Lunaria* it is fibrous, the fibres being but few. In *Asplenium Trichomanes* it is also fibrous, the fibres being numerous and closely matted together. In *Aspidium Filix-mas* it is at first also merely fibrous, but is converted in the process of vegetation into a large caudex, of which the fibres seem to be only appendages. In *Aspidium dilatatum* it is tuberous;† and in *Polypodium vulgare* it is creeping and covered with scales. In *Pteris aquilina* or common Brakes, it is sometimes described as being spindle-shaped,‡ but this is evidently not the fact.

---

* Withering, vol. i. p. 355.

† Smith's Flor. Brit. p. 1126. ‡ Ibid. 1136.

If a frond of this Brake is taken and pulled up with the hand, the lower extremity which is black and discoloured by having been partly sunk in the earth, and to which some small fibres are occasionally attached, is apt to be mistaken for the root, and has, I presume, been often mistaken for it. But the real root from which the frond has been thus detached still remains in the soil, extending itself in a horizontal direction, at the depth of from three to four inches below the surface, sometimes simple and sometimes branched, but always furnished with lateral fibres. Its thickness is about that of the lower part of the frond, the surface being of a dark and dusky colour partly covered with a velvety sort of down, and the frond issuing from it sometimes in clusters, but generally at considerable intervals. To what length an individual root may thus extend itself I have not yet been able to ascertain; but I have often taken up portions of root measuring from eighteen to twenty inches.

Modifications.

The Trunk.—In some Ferns the trunk is a cylindrical and upright stem; composed as it were of several tubes inserted into one another by the extremities, the insertions forming knots or joints, as in those of the straw of the Grasses; sometimes simple and sometimes branched, as in the genus *Equisetum*. In others the trunk, which is also a jointed stem, is weak and trailing, striking root at the joints, as in *Pilularia*. In the genus *Lycopodium* it is lash-shaped and creeping, though sometimes erect at the extremity. But in most of them, that is in the frond bearing Ferns, the trunk, if trunk it can be called, is a stipe supporting the frond, if it is not rather to be regarded as the base of the frond itself, and the plant altogether stemless. In *Polypodium Dryopteris* it is long and slender, if compared with the upper part of the frond; in *Polypodium calcareum* it is short; in *Asplenium Trichomanes* it is cylindrical; in *Pteris aquilina* it is flattened on the one side; in *Adiantum Capillus Veneris* the surface is smooth; and in *Aspidium Filix-mas* it is chaffy or beset with scales.

Modifications.

The Branch.—Ferns, in general, are not furnished with any part that can correctly be called a branch; though some Ferns are furnished with parts which are generally designated by that name. I believe they are peculiar to the genera *Equisetum* and *Lycopodium;* in the former of which they issue from the stem in whirls situated at regular intervals, and are in their structure similar to that of the stem itself, as being composed of a succession of distinct and tubular pieces inserted into one another. In the latter they do not originate in any regular order, but are also in their structure similar to that of the stem.

Figure and distribution.

The Leaf.—The leaf, like the branch, is not in general to be found in the tribe of the Ferns, at least as a separate and distinct organ. But leaves are to be found in the genus *Lycopodium,* in which they are generally of a strap-shaped figure, scattered promiscuously over the stem and branch, and often so closely crowded together as to overlap one another like the tiles of a house.

Definition.

The Frond.—The most general feature characterizing the growth and habits of Ferns is that of the frond, being an incorporation of the leaf, branch, and stipe, as in the genus *Scolopendrium*. In the early stage of its growth the apex is in most genera rolled inwards like a scroll, forming a number of convoluted curves, which are unfolded as the plant expands, the figure of the frond being ultimately lanceolate, as in *Aspidium Lonchitis;* or deltoid, as in *Asplenium Adiantum nigrum;* or oval, as in *Ophioglossum vulgatum*, and its position erect, as in *Asplenium septentrionale;* or spreading, as in *Aspidium dilatatum*. It is also simple, that is without divisions, as in *Ophioglossum*, or wing-cleft, as in *Polypodium vulgare;* or winged, that is either simply, as in *Osmunda Lunaria*, or doubly, as in *Osmunda regalis*, the wings being also either opposite, as in *Asplenium Trichomanes*, or alternate, as in *Aspidium Filix-mas*, and the portion of the frond to which they are attached being, as in the case of the fructification of the Grasses, denominated the *Rachis*.

Modifications.

Its magnitude, at least as regarding British species, is from a span in length, as in *Cyathea fragilis*, to three or four feet, as in *Pteris aquilina;*

but of some of the Exotic species the height is said to be upwards of ten feet.

SECTION II.

Reproductive Organs.

Fern-seed thought to be a non-entity.

Discovered.

As Ferns are destitute of conspicuous flowers, so they were at one time thought to be destitute also of seeds, and propagated nobody knows how. Hence the common opinion so prevalent in ancient times with regard to the non-entity,* or the invisibility† of Fern-seed; an opinion that is scarcely even now exploded among the vulgar, though demonstrated by botanists to be totally erroneous; the fruit or seed of Ferns being not only visible to the naked eye, at least in its aggregate mass as resulting from the mode of inflorescence affected by different genera, but even the individual seeds by the assistance of the microscope. The former must have been often seen, though evidently not attended to, by ancient botanists; and the latter are said to have been first discovered by Cole and Swammerdam about the year 1670, as well as distinguished from the capsules in which they are contained.

---

* Σπερμα δε ουκ εχει. Theoph. Περι Φυτων τὸ. I.

† *Gadshill.* We have the receipt of Fern-seed—we walk invisible. Hen. IV. Part I. Act I. Scene I.

It was still possible, however, that these naturalists might have been mistaken, as Ferns had not yet been propagated by the sowing of their seeds. But the experiment was at last instituted in the year 1789 by Mr. J. Lindsay of Jamaica, as also about the same time by Mr. J. Fox of Norwich. The result was in each case conformable to expectation, and Ferns were obtained from both sowings.*

Made to germinate.

The reality of Fern-seed being thus evinced, the next object of the cryptogamist was that of the discovery of the parts of the antecedent flower, the existence of which was inferred from analogy. But in pursuit of this object it cannot be said that cryptogamists have been hitherto so successful as one could wish. For although Hedwig, that most able and accurate of all cryptogamic investigators, has indeed detected the parts of the flower in a variety of genera, or, at least, organs which he presumes to be the constituent parts of the flower; yet there seems to be still some considerable degree of doubt among botanists with regard to the value of some of his conjectures, and a consequent want of acquiescence in the legitimacy of some of his conclusions.†

Presumed to originate in flowers.

But where the parts of the flower have not yet been detected, the botanist can, at least, direct his attention to the mode of fructification, and to the fruit produced.

Modes of fructification.

---

* Lin. Trans. vol. *ii.*

† Smith's Introduc. p. 488.

Radical. In some genera the fructification is radical, that is placed upon or rather near the root, as in *Pilularia* (*Pl.* VII. *Fig.* 1.) and *Isoetes,* which are generally regarded as Ferns, though the parts of the flower are so obvious as to render it doubtful whether they should not be transferred to the class of conspicuous flowers, rather than to that of the cryptogamic.* In the former the flowers issue from the bosom of the leaves, which are radical, and consist of a receptacle or calyx, anthers and pistils, ascertainable by the aid of the microscope,† the seeds being small and globular bodies lodged in the receptacle, and covered with a fine membrane. In the latter the flowers are immersed in the base of the leaf or frond, and consist also of a receptacle or calyx, anthers and pistils, ascertainable by a good magnifier, the seeds being small and globular bodies lodged in a capsule.‡

Axillary. In the genus *Lycopodium* (*Pl.* VII. *Fig.* 2.) the fructifications are axillary, that is issuing from the axils of the leaves, though exhibiting, as I believe even according to Hedwig, no parts analogous to stamens and pistils, but consisting ultimately of kidney-shaped capsules, containing many minute seeds.

Terminal. In the genus *Equisetum* the fructifications are terminal, consisting of a succession of whirls of target-shaped substances attached horizontally and condensed into a club-like spike terminating the stem; the targets being considered by Hedwig as forming each a calyx, to the under surface of which are attached several tubular cells, containing stamens and pistils, and ultimately, upon becoming capsules, containing the seed. In *Ophioglossum* and *Osmunda* (*Pl.* VII. *Fig.* 3.), in which the fructifications are also in spikes, issuing from a frond, Hedwig has discovered what he regards as both stamens and pistils. The capsules, however, are easily discerned, being of a globular figure arranged in two rows, and opening crossways when ripe with many minute seeds. In the former the spike is simple, in the latter it is branched.

---

* Smith's Introd. p. 488.

† Hedwig.

‡ Withering.

Dorsal. But in by far the greater number of Ferns the fructification is dorsal, that is scattered in clusters or patches on the back of the frond, as in the genera *Pteris* and *Scolopendrium* (*Pl.* VII. *Fig.* 4.), which together with their congeners are generally designated by the appellation of *Dorsiferous Ferns.* In these also Hedwig discovered what he believes to be the parts of the flower, not indeed including any thing like calyx and corolla, but stamens and pistils only, its primary and radical parts. If a frond of any of the dorsiferous Ferns is taken at a very early period of its growth and carefully unfolded, there may be seen with the assistance of a good miscroscope, dispersed over its under surface, but chiefly over that of the midrib, and sometimes also over the upper surface, a number of small globular bodies, which when put into a drop of water and placed

Conjectures of Hedwig.

under the highest magnifier, are found to consist of a small pedicle supporting a minute globule filled with a granulated mass. These Hedwig regards as stamens,* partly from the analogy of their figure, and partly from their disappearing in the mature state of the plant as the stamens in other plants disappear before the fruit ripens. The pistils he describes as globules sitting or supported upon pedicles, which are ultimately converted into the capsules that contain the seed ; but without specifically determining the stigma.

Of Bernhardi.

The above conjecture may, perhaps, be the fact, but must not be implicitly relied on, at least till supported by further evidence. And botanists do not indeed seem to regard it as of much value. Bernhardi, a later writer than Hedwig and an observer of great known accuracy, has introduced a different hypothesis founded upon a different view of the subject. He regards the white speck discoverable on the upper surface of the frond, which is opposite to the black spot or patch on the under surface, as the stigma of the dorsiferous Ferns, and the small globular bodies situated on the edge of the frond as the stamens. I am not acquainted with the reasons on which this conjecture is founded, not having seen Bernhardi's paper on the subject, but there seems a plausibility in it beyond that of Hedwig's, which, whether it is founded in truth or not, future observation must be left to decide. But if the fact were even decided, still it would be but of little practical utility to the botanist from the extreme minuteness of the parts, and consequent difficulty of observation, rendering them wholly unfit for the purposes of generic distinction.

---

* Theoria Fruct.

Institution of generic distinctions.

The fruit is, indeed, discoverable individually by the aid of the microscope, consisting for the most part of a capsule surrounded by an elastic and jointed ring opening transversely when ripe, and discharging the seed, which is a small and minute globule. But even this has been found insufficient for the purposes of generic distinction, the fruit of almost all the *Dorsiferous Ferns* being so nearly alike as to present no essential character sufficiently striking; and the situation and figure of the aggregate mass of fruit as assumed by Linnæus, being, by itself, at least defective.*

By Linnæus.

But besides the capsule already described as containing the seed, the fructification of the dorsiferous Ferns is also generally accompanied with an additional integument, called the *Indusium.* This is a thin and membranaceous substance covering the groups of capsules till the period of the maturity of the seed, each group having its separate *indusium,* originating for the most part in the nerves or veins of the leaf, but sometimes also in the margin. In some plants it is circular, in others longitudinal; in some it consists of one valve and in others of two valves, which at the period of the maturity of the seed burst or open, sometimes towards the nerves and sometimes towards the margin; but in plants of a similar habit uniformly in a similar manner. The merit of the discovery is due exclusively to Sir J. E. Smith, the learned president of the Linnæan Society of London, who has found it to be a most decisive criterion for the determining of natural genera, and the only sure ground on which the botanist can rely.* In his luminous and masterly Essay on the Genera of Dorsiferous Ferns, as also in his *Flora Britannica,* he applies to the integument in question the term involucrum, which is no doubt equally appropriate with indusium; but as the former term is already pre-occupied in the description of umbelliferous plants, it cannot with propriety be introduced into the description of Ferns.

---

* Smith's Tracts, p. 219.

By Sir J. E. Smith.

CHAPTER II.

MOSSES.

Their character.

The Mosses are a tribe of imperfect plants of a small and diminutive size, consisting often merely of a root surmounted with a tuft of minute leaves;

---

* Smith's Tracts, p. 227.

from the centre of which the fructification springs, but furnished for the most part with a stem and branches on which the leaves are closely imbricated, and the fructification terminal or lateral. They are perennials and herbaceous, approaching to shrubby; or annuals, though rarely so, and wholly herbaceous, the perennials being also evergreens.

And habitats.

Their most favourite habitats are bleak and barren soils, such as mountains, heaths, woods, where they are found not only rooted in the earth, but attached also to the roots and trunks of trees, and even to the flinty rock; or immersed in bogs and ditches, or floating, though fixed by the roots, in streams of running water. As they affect the most barren soils, so they thrive best also in the coldest and wettest seasons. In the drought of summer they wither and languish; but in the more moderate temperature of autumn they begin to recruit, so that even the chilling cold of winter that deprives other plants of their verdure and foliage, and threatens destruction to the race of vegetables, tends but to refresh and revive the family of the Mosses. Hence their capacity of retaining moisture for a great length of time without discovering any tendency to putrefaction, and of recovering their verdure when moistened with water, even after having been completely dried and kept in a dried state for many years. From the extreme minuteness of their parts they are apt to be overlooked by the superficial observer or disregarded by the novice in botany, who is attracted, perhaps, only by what is specious in the plant or flower, but who, when the desire of botanical knowledge shall have inspired him with a relish for microscopical observation, will find the study of the Mosses to be no less interesting than that of the more perfect plants, and the form and texture of their parts to be no less beautiful and elegant than that of the most gaudy flowers.

SECTION I.

Conservative Organs.

Modifications.

The Root.—The root is generally composed of a number of small and slender fibres closely matted together, as in *Tetraphis viridula;* or it sends down a thread-shaped caudex from which the fibres issue, as in *Polytrichum undulatum;* or the fibres are themselves branched, as in *Neckera viticulosa.* The direction of the root is generally somewhat oblique, as in *Polytrichum commune;* but it is often also creeping and horizontal, as in *Hypnum alopecurum.* The surface is for the most part smooth, but is sometimes covered with a fine and velvety down of a dark or rusty colour, as in *Funaria hygrometrica;* or the fibres issuing from the caudex assume that appearance, as in *Bryum undulatum,* one of the most beautiful of all British Mosses.

The Stem.—Some Mosses are altogether stemless, consisting merely of a root surmounted with a few minute leaves, as in the case of *Phascum muticum* (*Pl.* VII. *Fig.* 5.) and *Orthotricum Brownianum.*[*] Others are nearly stemless, no stem being visible without the aid of the microscope; and all are diminutive compared with herbs in general, few of them attaining to, and still fewer exceeding, a foot in height. But where a stem exists it is generally like the root, weak and slender, though sometimes stiff and shrubby, as in *Hypnum alopecurum.* It is simple, as in *Polytrichum commune;* or dichotomous, as in *Mnium palustre;* or branched, as in *Dicranum scoparium.* It is also erect, as in *Bryum ligulatum* (*Pl.* VII. *Fig.* 6.); or procumbent, as in *Hypnum rugosum;* or pendant, as in *Hypnum crispum;* or creeping, as in *Hypnum prælongum;* or floating, as in *Fontinalis antipyretica.* It is for the most part closely covered with leaves, though sometimes bare at the lower extremity, as in the barren plants of *Bryum roseum.* If the species grows in tufts or patches, a case by no means rare, the stems are generally, like the root, closely matted together, as in *Tortula ruralis.*

Sometimes wanting.

Modifications.

Sometimes the lower part of the stem sinks annually into the soil, where it sends out small fibres, and is converted into a root, the original root being now decayed and converted into vegetable

Sinking stem.

---

[*] Flora Brit. p. 1269.

mould. This observation occurs in Withering* as applicable to his *Hypnum parietinum*, the *Hypnum splendens* of Smith. But I conceive it to be an observation admitting of much greater latitude of application, the process in question being distinctly discernible not only in the case of *Hypnum splendens*, but in that also of *Hypnum prælongum*, *Bryum ligulatum*, and particularly *Tortula ruralis*, where the gradations of change are so very well defined as to be obvious to the sightest inspection. I have indeed found traces of this change more or less conspicuous in almost all species I have yet examined, and am inclined to believe that it pervades and characterizes the whole tribe of Mosses. If so, it will well account for their peculiar capacity of forming an original soil for the growth of larger vegetables even on the barren rock, to which they often cling.

Sometimes the stem is proliferous, that is when the shoot of the first year does not afterwards elongate by the extremity, and so constitute a main and uninterrupted stem, but sends out new shoots from the middle or near the top, which become ultimately the principal stems, the original stems being gradually converted into roots, as in *Hypnum proliferum* and others.

Modifications.

The Branches.—The branches are in their structure similar to that of the stem, and are distributed frequently without any regular order, as in *Hypnum riparium;* but often also, according to some determinate or specific mode, in which case they are sometimes fastigiate, as in *Dicranum viridissimum;* or faciculate, as in *Hypnum flagellare;* or distichous, that is so arranged as to give the stem a winged-like appearance, as in *Hypnum proliferum.* In their direction they exhibit varieties similar to those of the branches of other plants, being, according to the peculiarities of their respective species, erect, or ascending, or inflected, or reflected, or horizontal. The young shoots are sometimes designated by the proper appellation of *surculi;* though the present state of botanical nomenclature does not seem to stand much in need of the term.

---

* Withering, p. 853.

Description.

The Leaves.—The leaves of the Mosses, which are indeed very minute, are notwithstanding uncommonly elegant if viewed under the microscope. They assume a considerable variety of the forms specified in the description of the leaves of perfect plants, but the most frequent are the linear, the lanceolate, the oval, the concave. They are always, I believe, sessile,* though often decurrent or sheathing at the base; the margin being often beautifully waved or ornamented with minute serratures, and the apex, which is generally acute, being often also surmounted with a minute and slender process resembling a hair or thread. Most of them are furnished with a midrib, (by which they are often keeled), together with some parallel nerves; though many of them are altogether destitute of nerves, exhibiting an entirely smooth and even surface, as in *Hypnum splendens.* Some of them, however, are furnished with a sort of net-work of veins, intersecting one another and giving the whole a finely reticulated appearance, as in *Splachnum reticulatum* (*Pl.* VII. *Fig.* 7). Others are most beautifully dotted as well as reticulated, as in *Bryum punctatum;* and others are delicately streaked, as in *Hypnum striatum.* Their colour is generally of a most beautiful green mixed with a tinge of yellow, though when placed under the microscope and in a strong light most of them are diaphanous, discovering a sort of membranous texture, from which they derive the property of twisting or curling up when dry.

---

* Dillenius describes the leaves of one of his *Hypna* as being petiolate; but Hedwig contends that it is merely a portion of the stem detatched along with the midrib, when the leaf is torn off by pulling it downwards. Fund. Hist. Nat. Musc. chap. v.

Distribution.

In their distribution they are for the most part closely crowded together, and originating on all sides of the stem or branch, the apex of the lower overlapping the base of the higher in the form of tiles. In many species they are distichous or two rowed, giving the stem or branch a winged-like appearance, and diverging at an angle more or less acute, as in *Dicranum tamarindifolium;* but in some, though distichous or scattered in their insertion, the points are all directed to the one side of the stem, in which case they are said to be unilateral, as in *Hypnum cupressiforme.* In others they diverge at right angles or are reflected, and are arranged so as to point three ways, and sometimes even more, as in *Hypnum squarrosum.*

But besides the leaves proper to the species in general, plants producing barren flowers are frequently furnished with a peculiar sort of leaves, which are crowded together at the extremity of the branch or stem, so as to form terminating stars, by expanding in the form of rays, in which case they are larger and more elegant than the rest, as in *Polytrichum commune;* or so as to form a sort of terminating bud, in which case they are smaller than the rest, as in *Bryum extinctorium* and most of the *Hypnums.* The terminating stars, however, are often proliferous, having a new shoot issuing from the centre of the disk, as in *Polytrichum juniperum.*

Such is the general character of the leaves of the Mosses; but the *Buxbaumia aphylla* of Schmidel is said to be wholly destitute of leaves, and to be the only known species that is so.*

---

* Hedwig. Fund. Hist. Nat. chap. v.

SECTION II.

Reproductive Organs.

Mosses thought to originate in putrefaction.

THE fructification of the Mosses, though extremely elegant in its structure, is yet, at the same-time, so extremely minute as to be but seldom noticed except by botanists; by whom also it seems to have been long overlooked, or at the most but imperfectly investigated. The ancients who believed in the doctrine of equivocal generation, regarded the Mosses as a tribe of plants originating in the putrefaction of other vegetables, or in the accidental concourse of generative particles collected together by the alluvion of rains or rivers, and consequently as producing no flower or fruit. The earlier botanists of modern times seem to have regarded them in much the same light; and even the great and illustrious Tournefort, who published his Botanical Institutions about the beginning of the eighteenth century, when the doctrine of equivocal generation had begun to be more than suspected, and the doctrine of vegetable sexes admitted, at least in part, classes them along with Mushrooms and Sea-weed, under the title of *Aspermæ* or plants without seed. But this arrangement was now no longer regarded as being at all satisfactory; and botanists, who began to suspect that a distinction existed even in Mosses, were at last induced to undertake the irksome but indispensable task of a

And to be destitute of flower and seed.

minute and scrupulous investigation of the several parts and appearances of individual subjects during their several stages of growth, with a view to the discovery of sexual organs. Perhaps the first hint leading to a correct view of the subject was that given by Dillenius in his Appendix to his Catalogue of Plants growing in the neighbourhood of Gisse,* in which he regards the Mosses as being indeed without seed, but furnished with little heads containing a powder, by which the terminating leaves were rendered capable of germination.

Their fructification detected by Micheli.

But Micheli, inspector of the botanic garden at Florence, seems to have been the first of all modern botanists who obtained a complete view of the fructification of the Mosses, as consisting of a sexual apparatus, which he not only describes† but figures; though he appears to have been at the same time wholly ignorant of the respective functions of the organs he was describing, having mistaken the barren for the fertile flower; as well as perhaps altogether unacquainted with the true and legitimate doctrine of the sexes of plants.

And illustrated by Dillenius.

Dillenius who again resumed the subject in his *Historia Muscorum*, published at Oxford in 1741, a work that still stands unrivalled in this most difficult department of vegetable research, though he describes the flowers of the Mosses with great accuracy, and also with a view to sex, discriminating the barren from the fertile flower, as being sometimes produced on the same and sometimes on a different plant; yet he still unhappily mistakes the former for the latter, and, by consequence, the latter for the former, without having thrown any new light on this most important part of the history of Mosses, for which he was indeed so peculiarly well qualified.

---

* Giessæ, 1719. 8vo.

† Nova. Plant. Gener. p. 108, 1729.

And Linnæus.

Linnæus, whose original ideas on the fructification of the Mosses seem to have been correct,* by adopting as the ultimate result of his investigations the opinions, and consequently the errors, of Dillenius, left the subject involved in the same obscurity in which he found it; and by giving to error the sanction of his great name and authority, became, unfortunately, the occasion of misleading future inquirers, rather than of conducting them to the truth.

The elucidation of this obscure subject was afterwards undertaken by several contemporary or succeeding botanists, without much success; particularly by Hill in his History of Plants, in which he controverts the opinions of Dillenius and Linnæus on the subject of the fructification of the Mosses, and shows them to be erroneous; proving the capsula of the former and the anthera of the latter, both terms indicating the same idea, to be a real seed-vessel, by means of the experiment of sowing the powdery substance contained in it, and obtaining as the result a crop of young Mosses.†

---

* Smith's Introd. p. 490.

† History of Plants, chap. xliv.

This was of course an unanswerable argument, and a discovery of the utmost importance to the cryptogamist; and yet Hill's work has fallen into such unavoidable disrepute, that the service he thus rendered to the cause of botany is scarcely ever heard of.

Whose view of the sexual organs is proved to be erroneous by Hill.

But by thus disproving the opinion of Linnæus with regard to the anthers of the Mosses, he was now under the necessity of looking out for the true anthers in some other part of the flower or plant, which he at last discovered, as he thought, in the same flower, and in what he called the rays of the corona. But this opinion was soon found to be equally erroneous with that which he had just refuted, because it supposed the flowers of all Mosses to be hermaphrodite, which they are not in fact; and because the flowers of many of them are destitute of a corona altogether.

Who exhibits an erroneous view in his turn.

Several other opinions were subsequently advanced by Meese, Koelreuter, and Miller, hostile to the former and to each other, and tending only to show that the most profound mystery still enveloped the subject, or to introduce a degree of botanical scepticism inconsistent with impartial research, which discovered itself even in the celebrated Necker; urging him to exclaim rather too rashly that, whatever had been or might in future be said of the fructification of the Mosses he was determined to regard as a fiction or dream.

Researches of Hedwig.

In this stage of progress the celebrated Hedwig first began to direct his attention to the study of the Mosses, when perceiving all that had been previously done with a view to elucidate their fructification to present but a chaos of confusion and contradiction, he found it absolutely necessary to renounce all sort of dependance upon previous opinion and authority, and to examine every thing for himself. This he accordingly did with a degree of caution and scrupulosity, and patience, never yet surpassed; so that by employing glasses of a higher magnifying power than any preceding botanist, and taking no fact upon trust, he at length succeeded in obtaining a clear and complete view of the subject, in disencumbering it of the rubbish with which it had been so long clogged, and in presenting to the cryptogamist a superstructure, not the offspring of his own fancy, but the image of nature.

According to Hedwig, the Mosses, with regard to their fructification, are for the most part *Diœcious*, that is having the barren and fertile flowers on separate plants, as in the genus *Hypnum*, or *Polytrichum*. Many of them are, however, *Monœcious*, that is having the barren and fertile flowers distinct, but on the same plant, as in the genus *Phascum;* and a few of them are *Hermaphrodite*, that is having the barren and fertile flowers united and on the same plant, as in *Bryum aureum*.*

---

* Fund. Hist. Nat. Musc. chap. vi.

SUBSECTION I.

Stars or disks.

Barren Flowers.—The barren flowers of the Mosses are the stars (*Pl.* VII. *Fig.* 8.) or disks, and buds, described in the former chapter, as frequently terminating the branches, or sitting in the bosom of the leaves, and as being sometimes also proliferous. If they are taken and dissected with care and under a good magnifier, they will be found to consist of an assemblage of leaves or scales resembling the other leaves of the plant in form, but generally larger or more elegant, and sometimes also coloured, though never terminating in a hair. These Hedwig regards, though upon grounds somewhat questionable, as constituting the calyx of the barren flower.

Succulent threads.

If the leaves of this calyx are now taken and carefully stripped off in succession, the desector will find as he approaches the centre a number of small thread-shaped and succulent substances closely crowded together, and issuing from between the leaves; or if not so issuing, occupying the centre of the disk, and distinguishable into two different sorts, some consisting of an individual and transparent viscus, and others of a longitudinal succession of small and transparent vesicles united at the extremities, so as to exhibit a sort of jointed or necklace appearance. Both of them may be readily detected in the barren flowers of *Polytrichum commune*, if gathered in the month of May or June. The former Hedwig regards as stamens distinguishable into filament and anther, the anther longer and somewhat cylindrical, but generally approaching more or less to club or egg-shaped, and both not exceeding the one-fiftieth part of an inch in length. The latter or necklace looking substances, which are generally somewhat longer than the stamens though less in diameter, do not yet seem to be well understood. Hedwig, without pretending absolutely to decide upon their use, calls them merely the succulent threads that accompany the stamens, but seems at the same time to believe that they assist fecundation, by means of securing a plentiful supply of moisture;[*] while he infers the stamens to be such from the presumptive evidence of the similarity of their substance and structure to that of the stamens of perfect plants, and of their opening also at the top when ripe and discharging a fine pollen—which phenomenon may be seen by means of placing a stamen fully ripe under a high magnifier and wetting it with a drop of water. The summit of the anther bursts open and the pollen explodes.[†]

SUBSECTION II.

Distribution.

Fertile Flowers.—The fertile flowers of the Mosses are, like the barren flowers, generally terminal; but they are often also lateral or radical. They are not furnished with any integument that can be decidedly called a calyx, though the leaves immediately surrounding them are generally different both in size and structure from the other leaves of the plant; and in the genus *Hypnum* are so very obviously different as to have obtained the proper appellation of the *Perichætium* or Fence, being an assemblage of loosely imbricated scales terminating in a fine hair or bristle, rather than real leaves.

---

[*] Fund. Hist. Nat. chap. xi.

[†] Fund. Hist. Nat. Musc. chap. viii.

Fence.

Auxiliary pistils.

But if they are not to be regarded as constituting a real calyx, or part of the real leaves of the species, they are at least to be regarded as constituting floral leaves, both from their contiguity to the flower and analogy to the floral leaves and perfect plants. In their original distribution they form generally a sort of bud, from the centre of which the flower issues, presenting, when first discoverable, the appearance of a fine and minute point projecting from the bosom of the leaves. This incipient stage of growth is very distinctly visible in the fertile flowers of *Funaria hygrometrica* (*Pl.* VII. *Fig.* 9.), if gathered about the month of January, which are also accompanied with a number of succulent pistils somewhat similar to those described as accompanying the barren flowers, and equally unaccountable. Hedwig calls them auxiliary pistils, but does not pretend absolutely to determine their function;* and Dr. Smith thinks they may, perhaps, serve in either case the purpose of calyx, or of corolla, or of both.*

---

* Fund. Hist. Nat. chap. ix.

Sheath. But however this may be, the parts of the flower soon begin to assume a different appearance, as the process of fructification advances, the fine and pointed substances expanding into a sort of lengthened cone, invested by a thin and membranaceous integument, which is adherent at the base and summit, but inflated towards the middle, and which finally separates horizontally into two distinct portions. The under portion, which is placed within the perichætium, remains, as before, attached to the base of the fructification, and is designated by the name of the sheath; while the upper portion adheres also, as before, to the summit of the fructification, which it still partially invests in the form of an extinguisher. In this stage it has been called by some botanists a calyx, and by others a corolla.† But its resemblance to either is so extremely slight, as scarcely to justify the application of the term. It is more generally known, however, Calyptra. by the appellation of the calyptra or veil, a term sufficiently expressive of at least part of its functions, masking as it does, a globular or urn-shaped vessel, which is the capsule of the Mosses. In Capsule. some species this capsule is sessile, or very nearly so, as in *Phascum muticum;* but in by far the greatest number it is elevated upon a fine and often capillary but conspicuous pedicle, as in *Polytrichum*

---

* Introd. p. 489.

† Fund. Hist. Nat. Mus. chap. x.

commune. Sometimes it is erect, as in *Phascum patens;* and sometimes drooping, nodding, or pendulous, as in *Bryum cæspiticium.* The external surface is generally smooth, as in *Encalypta vulgaris;* but sometimes it is marked with longitudinal furrows, as in the *Genus Bartramia;* being when in a young state somewhat white or green; but when in a mature state, brown, red, or yellow.

Pedicles.

Like the capsules which they support, the pedicles are sometimes erect, as in *Bryum cylindricum;* and sometimes bent, as in *Bryum hornum.* They are generally solitary, but sometimes also aggregate, as in *Bryum ligulatum;* in which it is no unusual thing to find five or six of them issuing from the same point. In some species they are so very short as to be scarcely perceptible, and in others they are from one to three inches in length, as in *Polytrichum commune.* The surface is generally smooth and shining, as in *Hypnum nitens;* though sometimes it is also rough, as in *Hypnum lutescens.* Its colour is sometimes white and pellucid, as in *Grimmia contraversa;* but in a ripened state it is generally brown, yellow, purple, or red. At the base it is almost always sheathed by a thin and membranaceous substance, the lower portion of the original veil, and sometimes it is slightly bulbous, as in *Hypnum Teesdalii.* At the summit it is also often distended into a large bunch or protuberance of a globular or oval figure, upon which the capsule sits, as in the genus *Splachnum;*

Apophysis.

which protuberance is denominated the *Apophysis.*

Operculum or lid.

The mouth of the capsule is externally covered with an *operculum* or lid, assuming in different species a variety of different forms, and detaching itself horizontally when ripe. Sometimes it is flat, as in *Polytrichum alpinum;* and sometimes it is hemispherical, as in *Polytrichum undulatum;* but for the most part it is conical and acute. In its position it is erect, or oblique, or bent, or crooked; in its surface it is smooth or streaked; in its colour it is brown, red, or scarlet, when ripe.

Peristomium or fringe.

If this lid is stripped off, or detaches itself spontaneously, the mouth of the capsule is then found for the most part to be internally furnished with a circular and double row of fine and tooth-shaped substances, called the *peristomium* or fringe, sometimes united into one set, and sometimes divided into several sets. In some genera, however, it consists of only a single row of teeth, and in others it is altogether wanting, as in the genus *Sphagnum.* The number of the teeth is also variable in different genera, though generally uniform in the same; consisting in the genus *Tetraphis* of only four; in *Dicranum* of sixteen; in *Trichostomum* of thirty-two; and in some of the *Polytricha* of even double that number. In *Encalypta* the teeth are erect; in *Tortula* they are spirally twisted; and in *Dicranum* they are inflected at the top, and cloven half way down. In their ripened state they assume a tinge of brown, red, or yellow, as does also the lip of the urn or capsule, in which they are inserted.

Within the urn and in the direction of its longitudinal axis, there is situated a slender and cylindrical substance (*Pl.* VII. *Fig.* 10.) which seems to be a prolongation of the pedicle, passing through the whole extent of the urn, and perforating both lid and veil. This organ is designated by the appellation of the column; and its summit, which forms the apex of the flower, is regarded by Hedwig as the style of the Mosses. Column.

As the urn and column are concentric, there is formed by consequence between the inner surface of the one, and the outer surface of the other, a small and cylindrical cavity, which in the mature state of the fructification is filled with a fine powder consisting of a multitude of spherical granules of a brown, yellow, or greenish colour, generally smooth, but sometimes also dotted or prickly. These granules are the seeds of the mosses, from the sowing of which Hedwig obtained, as in the experiment of Hill, a crop of young Mosses, in all respects similar to the parent plants. The seeds.

Such is a short sketch of the herbage and fructification of the Mosses, according to the observations and discoveries of Hedwig, and of the theory founded upon them; namely, that the Mosses are, with a very few exceptions, either *Monœcious* or *Diœcious* plants, furnished with all organs essential

LIBRARY OF THE UNIVERSITY

to the constitution of a flower, and producing perfect seeds; a theory that seems at least to be founded in fact, and that has obtained the almost universal approbation of all succeeding botanists.

CHAPTER III.

HEPATICÆ.

Description and habitats.

THE Hepaticæ are a tribe of small and herbaceous plants resembling the Mosses, but chiefly constituting fronds, and producing their fruit in a capsule that splits into longitudinal valves. The name is derived from a Greek word signifying the liver, because perhaps some of them were formerly employed as a remedy in diseases of the liver; or because some of them exhibit, in their general aspect, a slight resemblance to the lobes of the liver. In their habitats they affect for the most part the same sort of situations as the Mosses, being found chiefly in wet and shady spots, by the sides of springs and ditches, or on the shelving brinks of rivulets, or on the trunks of trees. Like the Mosses they thrive best also in cold and damp weather, and recover their verdure, though dried, if moistened again with water. The Hepaticæ and the Mosses are indeed so nearly allied, that they have generally been regarded as constituting but one family, and classed together accordingly; the latter under the title of *Musci Frondosi*, and the former under that of *Musci Hepatici*. Such was the division even of Hedwig,* but later botanists have found it to be more consonant to the principles of sound and scientific arrangement, to separate the Hepaticæ from the Mosses altogether, and to convert them into a distinct tribe.

SECTION I.

Conservative Organs.

The Root.—Some of the Hepaticæ seem to be destitute of a root altogether, or are at least not furnished with any conspicuous root, as in *Jungermannia asplenoides*; but where a root is present it consists of a number of small and fibrous productions, issuing from the base or under surface of the herbage, and fixing it to the soil or substance on which it grows. **The root.**

The Herbage.—The herbage, in a few species, consists of a stem furnished with distinct leaves like the Mosses, as in *Jungermannia cochleariformis*, and some others, in which the leaves are so distributed as to give the shoot a sort of winglike appearance. But in the greater number the herbage is frondose, though not upright in its growth like the frond of Ferns (*Pl.* VII. *Fig.* 11.), being seldom furnished with any thing like a stipe; **The herbage.**

---

* Theoria Fruct. et Gener.

but creeping along upon the surface of the soil or substance to which it is attached, and striking root as it extends. Sometimes it is simple, and sometimes, as in *Jungermannia tamariscifolia*, branched or forked. It is also for the most part furnished with a midrib, from the opposite sides of which a number of circular and lobe-like leaflets issue, sometimes in a single and sometimes in a double row, overlapping one another, and assuming not merely a winged, but often a loricated appearance. In such species as have no midrib, the herbage consists merely of a cluster of circular and lobe-like substances growing out of one another, and lying flat on the ground, to which they are fixed by fibres issuing from the under side, as in *Marchantia polymorpha;* a mode of growth indeed common in some respect to the tribe, the shoots or branches being for the most part closely matted together, and interwoven into flat and dense patches. The structure of the lobes is also extremely beautiful, exhibiting when placed under the microscope, a fine net-work of vesicles frequently transparent. Their colour is generally green, but in *Jungermannia dilatata* it is of a dark brown, approaching to red.

SECTION II.

Reproductive Organs.

Analogous to the Mosses. THE reproductive organs of the Hepaticæ, in as far as they are yet known, are pretty much analogous to those of the Mosses; but the parts corresponding to the stamens and pistils of perfect plants do not appear to have been hitherto ascertained so satisfactorily as to leave no ground of doubt. In their flowering however they appear also, like the Mosses, to be either *monœcious* or *diœcious,* and perhaps even without exception, so that I believe no example of an hermaphrodite flower has yet been suspected among them.

SUBSECTION I.

Description.

Barren Flowers.—According to Hedwig the barren flowers of the Hepaticæ, which can scarcely be said to have any perceptible calyx or corolla, consist either of small and globular protuberances issuing from the summit of the plant, or from among the leaflets, or from the surface of the frond, constituting a viscus that contains a powdery substance which is the pollen, as in *Jungermannia;* or of small and minute granules surrounded with substances resembling the succulent threads of the Mosses, and imbedded in the body of the frond; or in target-shaped substances issuing from the surface of the frond, and elevated in conspicuous pedicles, as in *Marchantia.*

SUBSECTION II.

Their parts.

Fertile Flowers.—The fertile flowers consist for the most part of a double envelope, an outer and an inner; the former corresponding in some degree to the calyx, and the latter, which immediately invests the ovary and is surmounted with the style, to the corolla of perfect plants. The ovary, which in some species remains sessile, and in others is elevated on a pedicle, opens when ripe into several longitudinal valves, and discharges the seeds. The above parts and appearances are perhaps best exemplified in the genus *Jungermannia* (*Pl.* VII. *Fig.* 11.), as being the most extensive of the tribe, of which if a plant is taken and closely inspected even with the naked eye, in an early stage of its growth, there will be seen, besides the general herbage, a number of small oblong and sack-like looking substances, issuing from among the leaflets and assuming a position perpendicular to the surface of the frond. These sacks, which are the outer envelopes of the flower, if carefully opened up, will be found to contain an oblong or egg-shaped substance, which is the ovary wrapped up in a second envelope that is perforated by the style.

If this second envelope is now carefully stripped off, the ovary and style will appear accompanied with several succulent substances resembling the succulent and abortive pistils of the Mosses; and if the ovary is itself opened up it will be found to consist of a greenish and gelatinous mass, interspersed with a multitude of minute granules.

If the flower instead of being thus dissected is allowed to ripen on the plant, the envelopes will, in the progress of fructification, burst open at the top, and discover a small protruding globule of a black or brownish colour, and of about the size of a millet seed, which is by and by disengaged entirely from them, and elevated on a fine and thread-shaped pedicle from a line to an inch or more in length. This elevated globule is the ovary, which when ripe separates into four longitudinal valves, from the extremities of which a number of small spiral and elastic threads issue, to which the seeds are attached. In the genus *Marchantia* the pedicle supports a target-shaped substance, to the under surface of which the ovaries are attached. In *Anthoceros* the ovary is a conical substance issuing from the upper part of the frond and supporting a veil, which is the inner envelope. In *Blasia* it is a sort of egg-shaped substance sitting upon the under surface of the frond; and in *Riccia* it is a turban-shaped substance imbedded in the body of the frond. The Hepaticæ, like the Mosses, are capable of being propagated by the sowing of their seeds. But it has been observed by Hedwig and others that the Hepaticæ produce also gems as well as seeds, by which the species is often propagated. If a plant is carefully inspected there will occasionally be observed a number of small cup-shaped substances immersed in the frond, and toothed at the border. The cups are filled with a number of small granules which are the gems.

The species propagated both by seeds and gems.

CHAPTER IV.

ALGÆ.

Description and habitats.

The term Algæ, which is of Latin derivation, seems originally to have denoted any sort of plant or herb growing in sea-water. But among modern botanists it has a much more extensive signification, including not merely marine and many other immersed plants, but also a great variety of plants that are not even aquatics, agreeing however in the common character of having their herbage frondose, or but rarely admitting of the distinction of root, stem, and leaf, and their fructification imbedded, either in the substance of the frond itself, or in some peculiar and generally sessile receptacle. The most common distribution of the tribe of the Algæ is that by which they are divided into the six following genera: *Lichen*, *Tremella*, *Fucus*, *Ulva*, *Conferva*, *Byssus*. But future investigators will probably find room for considerable alteration.

SECTION I.

Conservative Organs.

Modifications.

The Root.—The Algæ are but seldom found to exhibit any evident traces of a distinct and decided root, though they are often attached to the substance on which they grow by means of a number of small fibres issuing from the edge or under surface of the frond, as in many of the *Lichens;* or by means of a small cylindrical and bony sort of substance issuing from its base or centre, as in several of the *Fuci.* An example of the former mode of radication may be seen in *Lichen caninus;* and of the latter in *Fucus nodosus.*

Varieties.

The Frond.—The figure and contexture of the frond differs so very much in the different genera of this tribe, as well as in many of the different species of the same genus, that it will be necessary to describe it in each.

In Lichens.

In the *Lichens* it is often merely a sort of powdery substance adhering to some accidental basis of support; or a flat and crustaceous expansion; or a leaf-like or shrub-like production; or a pulpy and gelatinous mass; but uniformly of terrestrial habitat, growing upon the surface of the ground, or on trunks and branches of trees, or on decayed stakes and pales, or on stones and barren rocks; and found also in all climates and seasons, being capable of resisting the cold and humidity of winter, as well as the warmth and drought of summer.

Byssi.

In the *Byssi* it consists often of a number of finely feathered threads, finer than those of a cobweb and closely matted together, which in their aggregate appearance frequently resemble a piece of soft and smooth velvet of a rich and beautiful colour; being also of terrestrial habitat, and grow-

HALLIDIE LIBRARY OF THE UNIVERSITY

ing on the bark of trees, or on rotten wood, or on stones and rocks, or in damp vaults or cellars, and on wine casks, where it is often so extremely fine and delicate, that the slightest breath or touch will disperse or dissolve it.

Tremellæ. In the *Tremellæ* it is a gelatinous and often pellucid substance of no regular or definite shape, but chiefly of terrestrial habitat, being found for the most part on decayed stumps and branches of trees, or on stones and gravel walks, or on meadows and pastures after rain, where it is sometimes found resembling a large lump of transparent jelly, which people unacquainted with botany are apt to regard as the congealed remains of what are vulgarly called shooting stars, after having fallen to the ground.

Ulvæ. In the *Ulvæ* it is a thread-like and tubular substance, or a flat waved and leaf-like membrane, or a sort of spongy and viscid pulp, chiefly aquatic, though partly marine and partly inhabiting pools or lakes of fresh water, and but rarely found on the surface of the earth.

Confervæ. In the *Confervæ* it is a fibrous and thread-like substance, jointed, forked, or branched, with the threads closely matted together, and extricable only by immersion; being wholly acquatic, but partly also marine, and partly inhabiting pools, cisterns, or rivulets of fresh water.*

---

* The subject of Fresh-water Confervas has lately been much illustrated by M. Jean Pierre Vaucher, of Geneva. Lit. Journ. vol. i. 491.

Fuci. In the *Fuci* it is sometimes capillary or cylindrical, and sometimes flat, with or without a midrib, sometimes jointed like a neck-lace, and sometimes leafy and shrub-like, and interspersed with a number of bags or bladders pellucid or opaque; being wholly marine and generally known by the appellation of sea-weed or sea-wrack, attaching itself to rocks and stones on the sea shore, so as to be laid bare at low water, but often also at such a depth as to be constantly submersed.

SECTION II.

Reproductive Organs.

Resemble warts. THE fructification of the Algæ is less perfectly known than that of any of the preceding tribes of imperfect plants, but it has received like them also considerable elucidation from Hedwig, particularly in as much as regards the *Lichens.* In all species of lichen there issues from the edge or surface of the frond a number of small tubercles, or wart-like substances, of the colour and contexture of the frond. If one of them is taken in an early stage of its growth, and divided by means of a vertical section, it will be found to consist of a single or double cell imbedded in the pulp of the frond, and containing a granulated mass. The contained granules are particles of pollen, the maturity of which is indicated by the changing of the colour of the tubercle to a deep brown, and their escape, by its changing to black.

Or targets.

From a different part of the same plant, or from a different plant of the same species, there are also found to issue a number of cup-shaped or target-shaped substances, sitting or supported on short pedicles of the same contexture with the frond, and of a sort of greenish colour, but gradually becoming dark as they ripen. If one of them is now divided by means of a vertical section, it will be found to ~~contain~~ immediately under the black crust at the top, a number of small and egg-shaped substances arranged in perpendicular columns. These substances are the seeds which finally escape through the crust. In this species both the barren and fertile flowers are well exemplified in *Lichen physodes*. (*Pl.* VII. *Fig.* 12.)

Which Gærtner regards as being merely gems, and constituting a propago.

Such is the theory of Hedwig. But, Gærtner who is also a great authority on this subject, contends that the powdery substance, ejected from the targets or saucers, consists, not of seeds, but of a peculiar species of gem, which he denominates the *Propago*, and describes as being a simple gem without leaves or regular shape, sometimes naked and sometimes covered with an envelope, which, separating at length from the parent plant, is dispersed in the way of seeds, but is not itself a seed. This is a subject on which it is, of course, difficult to decide, and which is likely long to baffle the researches of the botanists.

In the remaining genera of the Algæ, the fructification is if possible still more obscure, exhibiting no traces of stamens or pistils, or even of the warts and saucers of the *Lichens*, but merely a number of small granules, irregularly dispersed throughout the substance of the plant, and extricated only by its decay, which Hedwig presumes to be seeds; but which Gærtner regards also as a peculiar species of gem, and designates by the appellation of the *Gongylus*, describing it as being a simple gem without leaves, of a globular form and solid contexture, imbedded in the bark of the plant and extricated only by its decay; so that it may very well be doubted whether the genera in question do at all produce perfect seeds, or are propagated by any other means than that of gems. In the *Fuci* the interspersed granules are said to have a perforation above them, which the other genera have not.*

Or gongylus.

SECTION III.

Uses.

In medicine and the arts.

THE utility of the Algæ is obviously very considerable, whether we regard them as furnishing an article of animal food, or as applicable to medicine and the arts. The *Fucus edulis*, and several other *Fuci*, are eaten and much relished by many people whether raw or dressed, and it is likely that some of them are fed upon by various species of fish. When disengaged from their place of growth and thrown upon the sea shore, they are often collected by the farmer and converted into a manure. They are often also employed, as the name imports, in the preparation of dyes, as well as in the lucrative manufacture of kelp, a commodity of the most indispensable utility in the important arts of making soap and glass.

---

* With. Arrang. vol. iv. p. 83.

The *Lichen rangiferinus* forms the principal nourishment of the Rein-deer during the cold months of winter, when all other herbage fails. The *Lichen islandicus* is eaten by the Icelanders instead of bread, or used in the preparation of broths, and like the *Lichen pulmonarius* has been lately found to be beneficial in consumptive affections. Many of them are also employed in the preparation of some of our finest dyes, or pigments; and it is from the *Lichen Parellus* that the chemical analysist obtains his Litmus.

In the natural formation of soils.

The *Lichens* exemplify also more completely what was already noticed in the case of the Mosses, namely, the wise institution of nature in providing for the universal diffusion of vegetable life over the whole surface of the terrestrial globe. The powdery and tuberculous lichens attach themselves even to the bare and solid rock. Having reached the maturity of their species they die and are converted into a fine earth, which forms a soil for the tiled and leathery lichens. These again decay and moulder into dust in their turn; and the depth of soil, which is thus augmented, is now capable of nourishing and supporting other tribes of vegetables. The seeds of the Mosses lodge in it and spring up into plants, augmenting also by their decay the quantity of soil, and preparing it for the support of plants of a more luxuriant growth, so that in the revolution of ages even the surface of the barren rock is covered with a soil capable of supporting the loftiest trees.

CHAPTER V.

FUNGI.

Description and habitats.

THE Fungi are a tribe of plants whose herbage is a frond of a fleshy or pulpy texture, quick in its growth and fugacious in its duration, and bearing seeds or gems in an appropriate and exposed membrane, or containing them interspersed throughout its mass. But this rule is not without its exceptions; for many of the Fungi are converted, during the process of vegetation, or rather when their vegetation is over, into a tough, leathery, and even woody substance; which gives them a permanency beyond that of their congeners, and a trait of character that is not included in the above definition. They are also a tribe of plants that may be regarded as the lowest in the vegetable scale, exhibiting a considerable resemblance to the tribe of zoophites, and thus forming the connecting link between the vegetable and animal kingdoms. They have indeed been regarded by some naturalists as being in reality animal productions, formed in the manner of *Coralines;* and by others as being generated from the putrefaction of other vegetable substances, without springing from seeds or gems of their own production. The latter was the opinion of Theophrastus, Dioscorides, and Pliny, among the ancients; and the former was the opinion of Butner, Muller, and Scopoli, among the moderns. But these opinions have been long ago totally exploded, and the proof of the vegetable origin of the *Fungi* rendered indubitable by the detection of their seeds or gems. The habitats they affect are very various, many of them vegetating only on the surface of the earth, and some of them even buried under it; others on stumps, and trunks of rotten trees; others on decayed fruit; others on damp and wet walls; and others on animal ordure.

SECTION I.

Conservative Organs.

Often wanting.

The Root.—Many of the *Fungi* are altogether destitute of a root, or at least they are destitute of any conspicuous root; being attached to some appropriate basis of support merely by means of a large and flattened surface. Of those that have conspicuous roots some are furnished with a few fibrous productions, by which they may partly adhere to the soil or substance on which they grow, and partly absorb nourishment; and others with a knob-like protuberance, or with several such protuberances, which seem to constitute their root.

Modifications.

The Frond.—The frond, in many of the Fungi, is merely a thin, flat, and leathery sort of substance, adhering to a basis of support by means of the whole of its under surface, as in the *Boleti.* In others it is globular and sitting, as in *Lycoperdon;* and in others it is bell-shaped and sitting, as in *Nidularia.* But in a variety of genera it is also furnished with a stipe, which is erect or crooked; cylindrical or compressed; hollow or solid; varying in different species from the size of a crow-quill or less, to an inch or more in diameter; and from being almost sessile, to six or eight inches in height. Sometimes it is simple and sometimes branched, and sometimes beautifully coloured; but always destitute of foliage.

Pileus or cap.

Of the Stipitate *Fungi* (*Pl.* VII. *Fig.* 13.), a great many are furnished with a sort of conical or flattened production surmounting the stipe, and attached to it at right angles, sometimes by the centre, and sometimes by the one side. This production has obtained the appellation of the *Pileus* or cap, which its figure suggests, and may be exemplified in *Agaricus campestris,* or the common Mushroom. Its substance, like that of the stipe, is spongy, or leathery, or woody, and its diameter from a fraction of an inch to a span. Its upper surface is generally smooth, but sometimes also wrinkled or scaly, being frequently of a white or yellow colour, but often of a beautiful red.

Gills.

The under surface is furnished for the most part with a number of thin and flat substances, which are attached to it by the one edge, and distributed like the radii of a circle, resembling in their form the gills of a fish, and designated by the same name. Sometimes they are inserted separately; sometimes in pairs or sets; and sometimes they inosculate and grow into one another. They may be exemplified also in the *Agaricus campestris,* in which they are inserted individually, and are of a beautiful pink. The under surface of such as have not gills is furnished with a multitude of pores or tubes, as in *Boletus;* or with prickles, as in *Hydnum.*

Veil or curtain.

Of the cap-bearing *Fungi* the greater part are furnished with a fine, delicate, and cobweb-looking membrane called the *Veil* or *Curtain,* attached on the one hand to the circumference of the *Pileus,* and on the other to the circumference of the stem by which it is perforated, enclosing and protecting the gills. It may be exemplified also in *Agaricus campestris,* at least in an early stage of its growth.

For in an advanced stage, it disengages itself from the *Pileus* altogether, and often from the stem also, and perishes about the time of the maturity of the plant. But in some few species it is permanent, remaining still attached to the plant, sometimes by the *Pileus* in broken and detached fragments; and sometimes by the stem, round which it forms a circular protuberance or ring. In *Agaricus velatus* it envelopes the *Pileus*, entirely enclosing it as in a bladder.

Volva or wrapper.

In a few species of *Lycoperdon* and *Agaricus* there is to be found also an additional integument, of a tough and membranaceous contexture, generally simple, but sometimes also double, and enveloping the whole of the frond, at least in the early stage of its growth. This integument is called the *Volva* or Wrapper, which, as the enclosed substance expands, bursts into an aperture at the top, and splits into several longitudinal segments that are sometimes reflected to the very base, expanding like the rays of a star, and thus opening up a passage for the frond.

SECTION II.

Reproductive Organs.

First detected by Micheli.

The botanists who have been most successful in exploring the fructification of the *Fungi* are Micheli, Haller, Hedwig, and Bulliard. Micheli seems to have been the first to detect what may be regarded as the seeds of the *Fungi;* but Hedwig expected to find, and tried also to discover in them, as indeed in all cryptogamous plants, the same sort of reproductive organs as are found in plants with conspicuous flowers. And from a persuasion that they existed and were certainly to be detected, he was, in some cases, perhaps rather too soon, satisfied of having succeeded in their detection.

Stamens. In *Fungi*, furnished with *Gills* and a curtain, if the inner surface of the curtain is carefully examined with a good magnifier, before the time of its natural detachment from the stipe or *Pileus*, there will be found adhering to it a number of fine and delicate threads supporting small globules; and in such as have no curtain the same sort of substances may be found adhering to the edge of the *Pileus*. These Hedwig regards as stamens.

Pistils. If the *Gills* are next examined in the same manner and about the same time, there will be found sitting on their edge or surface a multitude of small tender and cylindrical substances, some of which are surmounted with a small globule, and others not. These he regards as being probably the styles and summits.

Similar substances may be detected on the other genera of *Fungi* also. But from the extreme minuteness of their parts, and from their strong similitude to the down with which the finer organs of vegetables are generally covered, it is easy to perceive how very difficult it must be to decide upon their true character.

Bulliard does not pretend to have discovered, and does not think it necessary that there should exist in the *Fungi*, organs exactly corresponding to the stamens and pistils of conspicuous flowers; but only organs analogous to them, and capable of performing similar functions; the grounds of which opinion he has illustrated in his Theory of the Fructification of the *Fungi*, and rendered at least as tenable as any that have been taken up against him. Gærtner is also of opinion that the *Fungi* do not in any case produce perfect seeds, but are propagated like the *Fuci*, by that peculiar species of gem which he denominates the *Gongylus*.

But however this may be, there can be no doubt that the *Fungi*, as well as the foregoing tribes of imperfect plants, do produce either seeds or gems, by which the species is propagated; and which are lodged either in an appropriate and conspicuous receptacle, or dispersed irregularly throughout the body of the frond.

Seeds.

In the genus *Agaricus*, and others of similar organization, this receptacle is the gills, in which, if inspected with a good microscope about the time the curtain bursts, there may be observed by means of raising up a small portion of the flat surface, a number of small and minute granules imbedded in their substance. These granules are the seeds or gems which in a ripened state are discharged in such multitudes and with such force that a piece of white paper put under the frond will soon be found covered with a fine and brown powder. In the genus *Boletus* this receptacle is the tubes; in the *Mucors* or Moulds, it is the globule surmounting the thread-shaped pedicle or stipe; in *Peziza* it is the upper surface of the frond only; and in *Clavaria* it is the general surface.

Models of Fungi.

As many of the *Fungi* are of the most rapid growth and evanescent duration, so they are also of the most tender and delicate contexture, and cannot possibly be preserved in a dried state so as to retain the habit and character of the vegetating plant. Hence some ingenious artists have endeavoured to remedy the defect by means of models in composition. Sowerby's are uncommonly correct, and are certainly well calculated to give the student a general notion of the form and habit of the species; but from whatever cause it arises, models do not seem to be much in request. Many of the *Fungi*, however, are also extremely hardy, and of comparatively slow growth, not attaining to the maturity of their respective species in less than a twelvemonth, and thus exposed to the action of all vicissitudes of season.

Uses.

The powder of the *Lycoperdons* is said to be an excellent styptic; and is remarkable also for its property of strongly repelling moisture. If a basin is filled with water and a little of the powder strewed upon the surface so as to cover it thinly, the hand may be plunged into it and thrust down to the bottom without being wetted with a single drop of water. Several of the *Boleti* when dried afford a very useful tinder; and several of the Agarics and Tubers are used as articles of food, or as ingredients in the preparation of seasoning. The Truffle is much esteemed for the rich and delicate flavour which it imparts to soups and sauces; and the Mushroom for its esculent property, and utility in the preparation of Ketchup.

BOOK II.

OF THE INTERNAL STRUCTURE OF VEGETABLES, OR THE ANATOMY OF THE PLANT.

Division of internal organs.

FROM the previous survey of the vegetable structure, it appears that the organs into which the plant is externally distinguishable are the root, trunk, branches, leaves, flower, and fruit, with their appendages. But the organs which are thus discoverable by external examination, are themselves reducible to component organs, which are again resolvable into constituent and primary organs. According to this view of the subject therefore, the plant consists of three distinct sets of organs, which we shall call the Decomposite, the Composite, and the Elementary—or final result of the analysis of the other two.

CHAPTER I.

DECOMPOSITE ORGANS.

Definition.

The decomposite organs are the parts which have just been enumerated as constituting the vegetable individual, and distinguishable by external examination; to the dissection of which we will now proceed, taking them in the retrograde order of the seed, pericarp, flower, leaf, gem, and caudex, or branch, stem, and root, with their decomposite appendages.

SECTION I.

The Seed.

Its successful dissection by Gærtner.

In the dissection and anatomy of the seed no botanist has been so successful as Gærtner. His work *De Seminibus et Fructibus Plantarum,* a work meritorious beyond all praise, while it furnishes the most finished model of corpological analysis that was ever presented to the world, exhibits also at the same time the most durable monument that could have been erected of the indefatigable industry and profound research of its author; so minute in his investigations that nothing has escaped him, and so faithful in his delineations that no one has ever surpassed him. Whoever, therefore, wishes to become well acquainted with the structure of seeds and fruits, without actually investigating every thing for himself; or to qualify himself for original investigation, by studying the works of the most approved master, must, like the candidate for literary fame to the models of classical excellence, give his days and his nights to the volumes of Gærtner. On this account I shall content myself with presenting to the reader a condensed view of the result of his investigations, distributed under such arrangement, and interspersed with such other observation, example, or remark, as shall seem most likely to give elucidation to the subject; with a view to which I shall first of all institute that division of the mass of the seed by which it is regarded as consisting of two principal parts distinguishable without much difficulty; namely, the integuments and nucleus, or embryo and its envelopes.

Division into two principal parts.

SUBSECTION I.

Invested by an epidermis,

Integuments.—The integuments proper to the seed are two in number, an exterior integument and an interior integument; which are sometimes, however, enveloped by the additional integument already noticed as constituting an appendage of the seed, under the title of the pellicle or seminal epidermis of Gærtner.

Or testa.

Article 1. *The Exterior Integument.*—The exterior integument which Gærtner denominates the *Testa* is the original cuticle of the nucleus, not detachable in the early stages of its growth, but detachable at the period of the maturity of the fruit, when it is generally of a membranaceous or leathery texture; though sometimes soft and fleshy, and sometimes crustaceous and bony. It may be very easily distinguished in the transverse or longitudinal section of the garden Bean or any other large seed, and may be also easily detached by the aid of a little manipulation. If it is detached entire it will be found to consist of one individual piece without any disruption of continuity, except that occasioned by the hilum or scar which is left by the fracture of the umbilical cord, (and which is to be perceived on the surface of every seed,) or by the foramen or aperture of Grew. In *Dysopyrus* and *Royena,* it has the appearance indeed of being composed of two valves, but when more minutely inspected it is found to consist of one only. It consists also for the most part of only one cell, but in *Sapindus* and a few others it has two cells. Its colour is generally of a deeper shade than that of the parts which it contains, as may be seen in the dissection of the seed of the common Privet, though sometimes it is also perfectly pellucid, as in *Oryza.* In some seeds it seems to be altogether wanting, as in *Rizophora, Caryophyllus,* and *Laurus,* in which, as Gærtner observes, it may probably have attached itself to the partitions of the pericarp.

Or subtesta.

ARTICLE 2. *The Interior Integument.*—The interior integument, which Gærtner has not designated by a proper name, but which I shall call the *Subtesta,* lines the exterior integument or *Testa,* and immediately envelopes the nucleus deriving its origin from the interior portion of the umbilical cord which after perforating the *Testa* disperses into a multiplicity of ramifications connected by a fine membrane, and forms the interior integument. Like the *Testa,* to which indeed it adheres, it may be easily distinguished in the garden Bean, or in a ripe Walnut; in which last it is a fine transparent and net-like membrane, which together with the *Testa* forms a rind that is generally peeled off before the kernel is eaten, as having rather a hot and bitter taste. To the superficial observer this rind appears, indeed, to consist of only one membrane, but when minutely inspected it is found to consist of two; which are respectively the *Testa* and *Subtesta,* or the exterior and interior integuments of the seed. The interior integument cannot in all cases be easily distinguished, but Gærtner is of opinion that it is always present, though often rendered inconspicuous by its adherence to, or incorporation with, the nucleus.

Like the *Testa* it consists also of one entire piece, of a soft and pulpy texture till the embryo has reached maturity, at which period it becomes membranaceous, and may generally be separated with ease from the nucleus, though not so readily from the *Testa.* At the point where the ramifications of the umbilical cord after having perforated the *Testa* commence, there is distinguishable upon the outer surface of the *Subtesta* a sort of scar or tubercle, which Gærtner denominates the *Chalaza,* coinciding with, or contiguous to, the hilum or external scar; but not always so, as it often happens that the umbilical cord, after penetrating the *Testa*, passes on without ramifications to the opposite side of the cavity, and there forms the *Chalaza* or internal scar, as in the case of the Cherry.

SUBSECTION II.

Its parts.

The Nucleus.—The nucleus is that part of the seed which is contained within the proper integuments, consisting of the albumen with the vitellus, when present, and embryo.

Or secundinæ internæ of Malpighi.

ARTICLE 1. *The Albumen.*—The albumen, a term introduced by Grew, in his Anatomy of Plants,* is an organ resembling in its consistence the white of an egg, and forming in most cases the exterior portion of the nucleus, but always separable from the interior or remaining portion. It was denominated by Malpighi the *Secundinæ internæ,*† and by Ventenat the *Perisperm,*‡ because in many seeds it invests the embryo; and because the term albumen is, in some measure, appropriated to chemistry, with which it is desirable that the terms of botany should not interfere. The latter reason is an argument of some weight against the use of the term albumen; but the former is no very strong argument in favour of the term *Perisperm,* because the organ it is meant to denote is also very often surrounded by the embryo, or nearly so, and situated in the centre of the seed, as in the *Caryophyllæ* and others. In the Grasses (*Pl.* VIII. *Fig.* 1.) and *Malvaceous* plants it forms the principal mass of the nucleus, though in many seeds it is scarcely perceptible; and in some, as in the seeds of *Leguminous plants,* and plants with compound flowers, it does not even exist, at least as a separate organ.

---

* Book iv. chap. iii.

† Opera Omnia.

‡ Tab. du Reg. Veg. vol. i. p. 491.

The figure of the albumen is generally that of the external integuments, roundish if the seed is roundish, and oval or otherwise if the seed is so. But to this rule there are many exceptions, particularly when the albumen is central. The surface, which is sometimes smooth and sometimes furrowed, is often also interrupted with chinks or clefts. When it is not itself central it contains internally a cavity or cell for the embryo, and sometimes two such cavities, of which the one has been said to be always empty:* but this is evidently contradicted by the example of the seed of the Missletoe, *Viscum album,* the albumen of which contains two cavities and two distinct embryos. Its substance, though Figure.

---

* Seneb. Phys. Veg. vol. ii. p. 198.

often such as the term albumen suggests, is by no means always so. In the Grasses it is farinaceous; in the *Umbelliferæ* it is woody; in the seed of Coffee-plant it is horny; and in that of the Date-palm it is said to be as hard as a stone.* Its colour is generally whitish; but in *Bocconia* it is yellow; in *Codon* it is red; and in the Missletoe it is green. Lastly, the albumen of most seeds is altogether without odour and without taste; but in Ginger, Nutmeg, and Pepper, it is sapid and aromatic.

Colour.

Its description.

ARTICLE 2. *The Vitellus.*—The vitellus is an organ of a fleshy but firm contexture, situated when present between the albumen and embryo; to the former of which it is attached only by adhesion, but to the latter by incorporation of substance, so as to be inseparable from it except by force. Hence, perhaps, it has been supposed to bear the same relation to the embryo which the yolk of the egg bears to the cicatricle; as well as to exhibit a character by which it may be always distinguished from the albumen, which is only contiguous to the embryo but not incorporated into it. It had been observed by Malpighi and others of the earlier phytologists, but not named nor distinctly characterized till it was studied and investigated by Gærtner; though even now there are many botanists who do not regard it as constituting a vitellus, but merely as a part of the embryo peculiarly organized. And the comparatively small

First named by Gærtner.

---

* Smith's Introduction, p. 291.

number of seeds in which it is present, together with its constant and close union with the embryo, furnishes them with arguments in support of their opinion.

But whatever may be the value of that opinion, or the contrary, the organ in question, though not very common, is by no means rare. It pervades the whole of the useful and extensive family of the Grasses, in which it is interposed between the albumen and embryo in the form of a scale (*Pl.* VIII. *Fig.* 1.), as well as of the several families of the Mosses, Ferns, and Fuci, in which, according to Gærtner, it constitutes the principal bulk of the seed, bearing an inseparable and germinating *cicatricle* upon its surface, and therefore not an albumen.

How distinguished from the albumen.

ARTICLE 3. *The Embryo.*—The embryo, which is the last and most essential part of the seed and final object of the fructification, as being the germe of the future plant, is a small and often very minute organ, enclosed within the albumen and occupying the centre of the seed, as in the *Umbelliferæ* and most plants, in which case it is said to be central; or enclosed within the albumen, but not occupying the centre of the seed, as in Asparagus, in which case it is said to be éccentric; or accumbent on the external integuments and consequently situated both without the centre of the seed and without the albumen, as in the Grasses, in which case it is said

Description, position, and parts.

to be peripherical. But if the seed is destitute of an albumen the embryo then occupies the whole of the cavity formed by the proper integuments, as in leguminous plants (*Pl.* VIII. *Fig.* 2.) and many others. It is discoverable for the most part in the transverse section of the nucleus, and is said to be found single in all known seeds, except that of the Missletoe, which contains evidently two distinct and entire embryos, imbedded in the substance of the albumen with the summits near the centre, and the radicles diverging to the circumference like the rays of a circle; the albumen being somewhat circular in its contour and lenticular in its mass, and measuring when ripe about one fifth of an inch in diameter; and the embryos being somewhat pestle-shaped in their aspect, and about one tenth of an inch in length. In some seeds it is so very minute as to present the appearance of being merely a simple and unorganized mass; but in by far the greatest number it is divisible into two distinct and conspicuous parts—namely, the cotyledon and plantlet.

The cotyledon.

The Cotyledon.—The cotyledon, a term introduced by Linnæus as a substitute for the term seed-lobe, is that portion of the embryo that encloses and protects the plantlet, and springs up during the process of germination into what is usually denominated the *seminal leaf*, if the lobe is solitary; or seminal leaves, if there are more lobes than one. In the former case the seed is said to be *Monocoty-*

ledonous; in the latter case, it is said to be *Dicotyledonous.*

Divisible into two lobes.

Dicotyledonous seeds, which constitute by far the majority of seeds, are well exemplified in the Garden Bean, in which the cotyledons appear, as in many other seeds, immediately under the proper integuments, in the form of two large lobes of a plano-convex figure, and fleshy but firm contexture; without indentations or divisions, having the flattened surface closely applied together, and forming conjunctively a sort of kidney-shaped figure, as well as constituting the principal mass of the seed, which has seldom any albumen if the cotyledon is large. In other cases the lobes are in their united figure cylindrical, as in *Pisonia;* or spiral, as in the Pomegranate; or sickle-shaped, as in *Canella;* or hooked and semi-circular, as in the *Lychnideæ;* or they are cleft, as in the Lime-tree; or keeled, as in the Privet; or hollowed out into cavities, as in the Beech. They are also, for the most part, divisible without much difficulty, as they are not united by the whole of their tangent surfaces, but only by a point situated somewhere in their circumference, and forming a small protuberance; though there are some examples, as in *Tropæolum,* in which the flattened surfaces do finally coalesce, about the time of the maturity of the fruit; as well as others in which, from the diminutive size of the seed, the division is not easily effected. In the former case the seeds should be examined before they are quite ripe, and in the latter they should be steeped for a while in some coloured infusion, such as may penetrate between the lobes and point out the line of division. Their colour is generally white or green, but in the ripe seed of leguminous plants it is yellow, and in the seeds of *Bideus* and *Zinnia* it is purple. They are generally without smell; if they have any it is not mild or aromatic. Their taste is for the most part hot and bitter; but in the Almond, Nut, and Walnut, it is sweet and grateful.

Not divisible into two lobes.

But although the greater part of seeds are, like the Pea and Bean, furnished with two cotyledons, there is at the same time a considerable number whose cotyledon consists of one lobe only, and may be exemplified, according to Gærtner, in the seeds of the *Scitamineæ*, *Gramina*, *Palmæ*, *Orchideæ*, and *Liliaceæ*, though the three last of these families seem now by some botanists to be regarded as improperly placed under this division of vegetables.*

On this subject I can say nothing from my own observation, having never had an opportunity of watching the germination of the seeds in question; but from Gærtner's universally aknowledged accuracy, I am altogether at a loss to conceive how he could have been so egregiously mistaken in a case coming immediately under his own inspection; and must confess myself to be still somewhat sceptical with regard to the propriety of any arrangement that would transfer the plants in question to any division of vegetables different from that in which he has placed them.

---

* Smith's Inquiry into the Structure of Seeds. Lin. Trans. ix.

The cotyledon of grasses.

The opinion of Gærtner with regard to the Grasses has been also denounced as erroneous;* not in supposing them to be furnished with a cotyledon, that is indivisible into lobes, for that is admitted; but in regarding the sheath that invests the plantlet as being their cotyledon: which opinion I do, however, most confidently adopt, for reasons founded on a minute investigation of the subject, which I may perhaps have an opportunity of introducing in the sequel of the work.

Of the onion and water plantain.

The *Scitamineæ* then is the only one of the above mentioned tribes about the cotyledon of which, according to Gærtner's view of the subject, there seems to be no dispute. But as the British phytologist can have but few opportunities of observing the germination of such plants, I shall point out an example or two to which he can have easy access, and in which he may trace the phenomena of the germination of plants furnished with a single-lobed cotyledon only, without going far from his home. These are first, *Allium Cepa* or the common Onion, which is to be found in every garden; and secondly, *Alisma Plantago* or Water Plantain, which is to be found in almost every pond or ditch.

---

* Smith's Inquiry into the Structure of Seeds. Lin. Trans. ix.

In the former case he must frequently inspect the Onion bed about the time the plants are coming up; and in the latter case he has only to take up a little of the mud near one of the plants of *Alisma* in the spring, and keep it moist with water in a flower-pot, and the self-sown seeds will soon begin to sprout; or the seeds may be gathered when ripe, and kept to be sown on purpose in the spring.

Cotyledons divisible into several lobes.

As there are some seeds whose cotyledon consists of one lobe only, falling short of the general number, so there are also a few whose cotyledon is divisible into several lobes, exceeding the general number. They have been denominated polycotyledonous seeds, and are exemplified in the case of *Lepidium sativum* or common Garden Cress, in which the lobes are six in number; as in that also of the different species of the genus *Pinus*, in which they vary from three to twelve. In the former case they are circular in their vegetating state; and in the latter they are lanceolate, originating in a whirl. The Mosses, as it appears from the observations of Hedwig,* should perhaps be referred to this division also; the lobes of the cotyledon being in them numerous beyond all other examples, though the propriety of this arrangement will depend entirely upon the particular view that is taken of the subject, as relative to the seed only, or to the evolved plant. For the classes that are pure in carpology, are not always pure in phytology;† a seed that is itself acotyledonous may yet in germination produce a plant that shall be furnished with a cotyledon, which seems to be the case with the Mosses. It should also be further observed that there are cases in which a seed having naturally but two lobes may by accident acquire a greater number. I have more than once opened a Hazel-nut whose kernel or cotyledon consisted of three lobes instead of two, its usual number. The lobes were nearly of an equal size, each consisting of about a third part of the kernel, and approaching to the shape of a triangular prism. The kernel was externally of the usual shape, and perfectly sound and good.

---

* Fund. Hist. Nat. Musc. part ii. 25.

† De Sem. vol. ii.

There is yet an additional distinction that has been instituted among cotyledons, and that may be here taken notice of. It is that by which they are divided into *Epigæan* and *Hypogæan cotyledons*. The *Epigæan* cotyledons are such as spring up during the process of germination above the surface of the earth, and are converted into what are usually called seminal leaves; being sometimes thick and fleshy lobes, as in the case of leguminous plants, and sometimes thin and foliaceous as in the case of the Carrot and Radish, though generally different both in shape and structure from the future leaves of the plant. The *Hypogæan* cotyledons which are peculiar perhaps to dicotyledonous seeds, are such as do not discharge any conspicuous function during the process of germination, or undergo any perceptible evolution, but remain enclosed within the proper integuments of the seed, and concealed under the surface of the earth. They are exemplified in the case of the Horse-chesnut and Walnut.

Acotyledonous seeds.

But although by far the greater number of seeds are furnished with two cotyledons, or with a cotyledon visible or not divisible into several lobes, there is also a considerable proportion in which the cotyledon is altogether wanting, or at least believed to be wanting by botanists in general. These, according to Gærtner, are exemplified in the Fuci, Ferns, and Fungi, the embryo being merely a germinating cicatricle imbedded in the surface of a vitellus which forms the mass of the seed.

But Hedwig, to whose opinions on this subject much deference is also due, maintains that the seeds of the plants in question are furnished with cotyledons as well as those of other plants, and that no seed whatever is without them. This is a case, however, in which the general opinion of botanists is against him, as may be seen from the many systems founded upon the presence, or absence, or number of the cotyledons, and exemplified in that of the great and justly celebrated Jussieu, whose primary divisions are those of *acotyledonous*, *monocotyledonous*, and *dicotyledonous* plants, the *polycotyledonous* being, perhaps, thought to be too few in number to constitute a separate division. It should be recollected, however, that the above divisions were instituted at a time when the subject had not yet undergone any thing like a rigorous scrutiny, that already many changes have been found necessary, and that future investigations will in all probability point out the necessity of more. In watching the germination of Fern-seed, Mirbel observed some substances which he regards as cotyledons, and so far supports the position of Hedwig; but whether he represents them as being monocotyledonous, or dicotyledonous, I do not now recollect, as it is several years since I have seen his book.*

The Plantlet.—The Plantlet, which implies merely the future plant in miniature, is the interior and essential portion of the embryo, and seat of vegetable life. In some seeds it is so minute as to be scarcely perceptible; while in others it is so large as to be divisible into distinct parts, as in the Garden Bean (*Pl.* VIII. *Fig.* 2.), in which it is situated near the scar, being partly lodged within the lobes, and partly in a small and conical process, projecting beyond the general line of their circumference and uniting them together.

Its parts.

The portion that is lodged within the lobes corresponds to the *caudex ascendens* of Linnæus, being the rudiments of the future leaf and stem, and generally denominated the plumelet; and the portion that is lodged within the conical process corresponds to the *caudex descendens* of Linnæus, being the rudimenta of the future root, and generally denominated the radicle.

---

* Trait. d'Anat. et Phys. Veget.

The radicle.

This conical and projecting process, which is very evident in the Bean, has generally been regarded by botanists as being wholly a Radicle, and accordingly described as such. But Mr. Knight has shown, by the most satisfactory evidence, that it is, externally at least, merely the part from which the radicle proceeds, and not the radicle itself. And if any one will take the trouble of examining the process in the seed of the Horse-chesnut he may soon satisfy himself of the fact, if he is at all dexterous at dissection; its external portion being merely a prolongation of the lobes of the cotyledon, uniting them together and investing not only the radicle but the plumelet also.

The radicle is the most constant of all the parts of the seed, being often found, at least by means of its integuments, where the plumelet is not at all perceptible. Its most simple form is that of a white point or speck upon the surface of the nucleus, though it is also often to be found in the form of a cylindrical or conical process, as already described. Sometimes it is longer than the cotyledons, that is as invested with its integuments, as in *Rizophora;* and sometimes it is shorter, as in leguminous plants. It is generally, or rather almost universally, solitary, except in the seeds of *Secale*, *Triticum*, and *Hordeum*, according to Gærtner. But the appearances are certainly the same also in the genus *Avena*, from which I should have, perhaps, inferred that they are the same in all Grasses whatever. But as Gærtner seems to deny this position I shall not insist upon it at present. It is said to be superior if situated near the summit of the seed, as in the *Umbelliferæ ;* and inferior if situated near the base of the seed, as in Compound Flowers. But it is always itself regarded as the base of the plantlet, commencing at the point in which the plantlet and cotyledon unite.

The plumelet.

The Plumelet, so denominated from its resemblance in some examples to a small feather, issues immediately from the radicle, and is the summit of the infant plant. It is not discoverable in what are called monocotyledonous seeds, except, as it is said, in a few of the Grasses ; and even in seeds called dicotyledonous it is not always easily detected. But it may be very easily detected in the Garden Bean, by means of gently opening up the lobes of the cotyledon, between which it lays enclosed in the form of two small leaflets pressed close together, and intersected with a number of fine nerves or veins.

Gærtner has distinguished plumelets into two different sorts, the simple and the compound, although it seems to be a division of no great utility. The plumelet is simple if the leaflets are sessile and in opposite pairs, as in the Laurel ; and compound, if if they are supported upon a common petiole, as in the Walnut. In the former case the leaflets are cylindrical, oblong, or ovate, as in most seeds; or they are spiral, as in *Gyrocarpus Jacquini.* In the latter they are conjugate, as the Tamarisk; or digitate, as in the Horse-chesnut; or crowded, as in *Lathyrus.*

Incipient stem.

But though the plumelet issues for the most part immediately out of the radicle, without the intervention of any thing like an incipient stem; yet there are some plantlets, such as those of the seeds of *Persimon*, *Viscum*, and *Berberis*, in which the vesteges even of an incipient stem may be discerned; so that it may truly be said that there is no part of the full-grown plant that does not already exist in miniature in the tender embryo, waiting only the concurrence of favourable circumstances to give it evolution.

SECTION II.

The Pericarp.

Reducible under all its modifications of

THE Pericarp, which in different species of fruit assumes so many varieties of contexture, acquires its several aspects not so much from a diversity of substance as of modification.

Capsule,

The valves of the Capsule, but particularly the partitions by which it is divided into cells, are composed of a thin and skinny membrane, or of an epidermis covering a pulp more or less indurated, and interspersed with longitudinal fibres. The capsule of the Mosses is composed of a double and net-like membrane, enclosed within a fine epidermis.

Pome,

The Pome is composed of a fine but double epidermis, or, as Knight says, of two skins, enclosing a soft and fleshy pulp, with bundles of longitudinal fibres passing through it, contiguous to, and in the direction of, its longitudinal axis.

Legume,

The valves of the Legume are composed of an epidermis enclosing a firm but fleshy pulp, lined for the most part with a skinny membrane, and of bundles of longitudinal fibres, forming the seam.

Nut-shell,

The Nut-shell, whether hard or bony, or flexible and leathery, is composed of a pulp more or less highly indurated, interspersed with longitudinal fibres, and covered with an epidermis.

Drupe,

The Drupe is composed of an epidermis enclosing a fleshy pulp, which is sometimes so intervoven with a multiplicy of longitudinal fibres as to seem to consist wholly of threads, as in the Cocoa-nut.

Berry,

The Berry is composed of a very fine epidermis enclosing a soft and juicy pulp.

Strobile,

To epidermis, membrane, pulp, and fibre.

The scales of the Strobile are composed of a tough and leathery epidermis, enclosing a spongy but often highly indurated pulp interspersed with longitudinal fibres that pervade also the axis.

SECTION III.

The Flower-stalk and Flower.

Composed of epidermis, parenchyma, and fibre.

THE Flower-stalk, or peduncle supporting the flower, which is a prolongation of the stem or branch, or rather a partial stem attached to it, if carefully dissected with the assistance of a good glass will be found to consist of the following several parts: 1st, *An Epidermis*, or external envelope. 2dly, *A Parenchyma*, or soft and pulpy mass. 3dly, Bundles of longitudinal *threads* or *fibres*, originating in the stem or branch, and passing throughout the whole extent of the parenchyma.

As exemplified in

The several organs of the flower are merely prolongations of the component parts of the flower-stalk, though each organ does not always contain the whole of such component parts, or at least not under the same modifications. The epidermis, however, and parenchyma are common to them all; but the longitudinal threads or fibres are seldom if ever to be found except in the calyx or corolla.

The calyx,

In the Calyx the epidermis is thicker on the exterior surface than on the interior surface; and the threads or fibres which in the peduncle formed but a few bundles, are subdivided into a variety of ramifications constituting a thin and flat network, of which the meshes are filled up with parenchyma.

Corolla,

The Corolla, though much more delicate in its texture than the calyx, exhibits by dissection the same component parts, which are distributed also in the same manner.

Filaments,

The Filaments seem to consist merely of a parenchyma enveloped by a fine epidermis, without exhibiting any traces of longitudinal threads or fibres, with which however they are said to be occasionally furnished.* In the Tulip the filaments are tubular, which is, as I believe, a rare occurrence.

Pistil, and

The Pistil, like the filaments, appears to consist merely of a parenchyma enveloped by a fine epidermis, except on the stigma; though the longitudinal threads or fibres so numerous in the calyx and corolla are said to have been occasionally detected in it also.†

In leguminous and liliaceous plants the style is evidently tubular, and has been suspected to be so in all plants whatever. But it would require a much more extensive induction of particulars than has yet been made to enable any one to speak with certainty on the subject.

Ovary.

The Ovary is at first, like the rest of the pistil, a soft and pulpy mass, in which the parts of the contained fruit cannot yet be distinguished, nor the fibres by which it is connected with the foot-stalk. But as the germe begins to expand, and to acquire a greater degree of consistence, its parts and mode of attachment are rendered perceptible. In its early state, however, it presents but little to the view

* Seneb. Phys. Veg. vol. ii. p. 60. † Ibid p. 84.

of the dissector beyond that of a few bundles of fibres dispersed throughout a pulpy parenchyma, and enveloped by a bark or epidermis. But when the flower has once fallen, and the ovary attained to its utmost magnitude, and the fibres and parenchyma of the peduncle have begun to become firm and woody, the fruit begins also to assume a mature and ripened aspect, and gradual change of consistence; exhibiting its last degree of developement and solidity, and consisting of the pericarp and enclosed seed.

SECTION IV.

The Leaf-stalk and Leaf.

Composed also of an epidermis, pulp, and bundles of longitudinal fibres.

THE Leaf-stalk, or petiole supporting the leaf, which is a prolongation of the branch or stem, or rather a partial stem attached to it, exhibits upon dissection the same sort of structure as the peduncle—namely, an epidermis, a pulp or parenchyma, and bundles of longitudinal threads or fibres.

The Epidermis, which is a thin and fine membrane, discovers when detached the enclosed parenchyma and interspersed fibres, which are generally in three, five, or seven sets, appearing like round transparent points upon a transverse section, or like thick and strong threads upon a longitudinal section; being always most distinguishable at the base, where they occasion a considerable protuberance; and occupying in their distribution a line forming a circle, or a section of a circle, upon which the external form of the petiole depends. If the circle is completed in the distribution of the several bundles, the petiole is cylindrical; and if the circle is not completed, it is then semi-cylindrical, being concave above and convex below, and thus presenting, like the leaf, two different surfaces.

The expansion of the leaf, which is merely a prolongation of the petiole, discovers upon dissection the same component parts, though differently modified. If a leaf is taken and torn asunder, either in a transverse or longitudinal direction, fragments of a fine and transparent pellicle will be seen projecting beyond the edge of the torn part. This is the epidermis. It may be detached in large portions from the leaf of the common Sorrel; but enough of it may be detached from the surface of almost any leaf for the purpose of microscopical inspection.

The fibres forming in the expansion a net-work,

When the epidermis is stripped off, the parenchyma is then laid bare, being of a green and pulpy substance, constituting for the most part the mass of the leaf, interspersed with the prolongations of the fibres of the petiole, which are now divided into a prodigious number of ramifications mutually embracing and intersecting one another, and forming a sort of fabric similar to a piece of fine net-work. The principal fibre, extending from the base to the apex of the leaf, forms what is called the midrib, and the ramifications form what are called the nerves and veins, the nerves being composed of the larger bundles of fibres, and the veins of the smaller bundles. In simple leaves, whether entire or indented, whether petiolate or sessile, the fibres of the petiole or base branch out into several large and principal nerves expanding like the ribs of a fan, and diminishing in size as they elongate by means of the ramifications they send out, till they are at last lost in the margins. There are examples, however, in which the fibres or nerves of the expansion project beyond the margin, and hang down in the form of threads, as well as others in which they fall short of the margin, the leaf being bounded by a thin and membranaceous border that seems to be merely a prolongation of the epidermis.

Sometimes three or more of the principal nerves, as in Narrow-leaved Plantain, take rather a vertical direction, and extend from the base to the apex of the expansion. But in leaves that are lobed or divided, the division is always formed by a principal nerve proportioned to the size of the lobe. The form of the expansion therefore depends upon the peculiar mode of ramification assumed by the fibres after quitting the petiole. In the Grasses, indeed, the distinction of the fibres of the petiole or sheath investing the stem is already analogous to that of the expansion of the leaf, except that the bundles or nerves are fewer in the former than the latter, branching out into minuter divisions as they ascend obliquely from the one into the other.

Which consists of two,

But the circumstance which is the most singular is that the fibres are not only subdivided into a variety of ramifications forming a fine net-work, but that the net-work is double (*Pl.* VIII. *Fig.* 3.), consisting of two layers, the one corresponding to the upper, and the other to the under surface of the leaf. Hollman detected and separated them in the leaf of the Pear-tree,* and Linnæus in the leaf both of the Pear and Apple-tree. He even discovered their points of union, and remarked that the net-work corresponding to the under surface was much less firm and compact in its texture than that corresponding to the upper surface. Hedwig discovered two layers, even in the minute and tender leaf of *Sphagnum palustre*, and affirms that he found, in the leaves of the Pear and Orange-trees, three layers of net-work,† which I have not indeed been able to detect in the former. But no language is able to convey an adequate idea of the delicacy and intricacy of the web. It must be inspected as it exists in the contexture, or rather in the decay of the leaf, whole leaves being often found reduced to a skeleton of fibres in the winter or spring, lying at the roots of trees in situations where they have not been dispersed by the wind. But if they are not to be found ready prepared as in this case, the dissector must have recourse to maceration.

And sometimes of three layers.

---

* Phil. Trans. 1741.

† Fund. Hist. Nat. Musc. chap. v.

SECTION V.

Gems.

Divided into four species.

In the previous description of the external structure of the plant, it has been shown that there exists among the different tribes of vegetables four distinct species of gems—two peculiar to perfect plants, the bud and bulb—and two peculiar to imperfect plants, the *Propago* and *Gongylus*; the latter being denominated simple gems, because furnished with a single envelope only; and the former being denominated compound gems, because furnished with more than a single envelope.

SUBSECTION I.

Consists externally of scales.

The Bud.—Buds, as was observed in the former book, are composed externally of a number of spoon-shaped scales overlapping one another, and converging towards a point in the apex, and often cemented together by means of a glutinous or mucilaginous substance exuding from their surface.

If these scales are stripped off and dissected under the microscope, they will be found to consist, like the leaves or divisions of the calyx, of an epidermis enclosing a pulp interspersed with a net-work of fibres, but unaccompanied with longitudinal threads, at least in such specimens as I have dissected. The epidermis, on the outer side of the scale, is of a much stronger contexture than that of the inner side, and much more easily detached, as may be seen in the scales of the buds of the Horse-chesnut and Filbert; in which last the inner epidermis is so incorporated with the pulp, as to be detachable only in very small portions.

But as buds produce either leaves or flowers, or both, it was to be presumed that the leaves and flowers must exist in an incipient state in the bud, long before the period of their evolution; which presumption the dissection of buds has shown to be the fact.

And internally of the rudiments of leaves and branches,

If the scales of a leaf-bud are taken and stripped off, and the remaining part carefully opened up, it will be found to consist of the rudiments of a young branch terminated by a bunch of incipient leaves imbedded in a white and cottony down, being minute but complete in all their parts and proportions, and folded or rolled up in the bud in a peculiar and determinate manner. This has been denominated the foliation of plants, and reduced by Linnæus to ten different modes.* 1st, The *Involute* (*Pl.* VIII. *Fig.* 4.), in which the lateral margins of the leaves are rolled inwards on both sides, as in the Apple, Poplar, and Violet. 2dly, *The Revolute* (*Pl.* VIII. *Fig.* 5.), in which the lateral margins of the leaves are rolled backwards on both sides, as in the Water Lily, Primrose, and Pellitory. 3dly, *The Obvolute* (*Pl.* VIII. *Fig.* 6.), in which the margins of one leaf are enclosed within the margins of another, as in Pink, Valerian, Sage. 4thly, *The Convolute* (*Pl.* VIII. *Fig.* 7.), in which the leaf is rolled up in the form of a scroll, the one margin being in the centre and the other in the circumference, as in *Arum,* the Apricot, and many of the Grasses. 5thly, *The Imbricated,* in which the several leaves overlap and infold one another in the manner of tiles, as in Privet, Spurge, and Laurel. 6thly, *Conduplicate* (*Pl.* VIII. *Fig.* 8.), in which the leaf is folded up into two parallel halves, extending from the midrib to the margin, as in the Oak, Beach, and Cherry. 7thly, *The Equitant* (*Pl.* VIII. *Fig.* 9.), in which the leaves are conduplicate but enclosing others, as in *Iris, Acorus,* and *Carex.* 8thly, *The Plaited* (*Pl.* VIII. *Fig.* 10.), in which the leaves are doubled up like the folds of a fan, as in *Alchemilla vulgaris* or Ladies' Mantle. 9thly, *The Reclined,* in which the leaves are bent back towards the foot-stalk, as in *Aconitum, Adoxa, Anemone.* 10thly, *The Circinal* (*Pl.* VIII. *Fig.* 11.), in which the leaves are rolled in spirally, as in the Ferns, and some of the Palms.

---

* Phil. Bot. Tab. x.

Or flowers, If the scales of a flower bud are taken and stripped off, and the remaining part carefully opened up, it will be found also to consist of the rudiments of an incipient flower, exceedingly small and minute, but complete in all its parts. This operation was performed in the month of January by Du Hamel, on the bud of a Pear-tree, and the following was the result.* The scales, which were from twenty-five to thirty in number, were found to contain from eight to ten flowers attached to a common foot-stalk of half a line in length. The flowers in their aggregate aspect resembled Rose-buds set with hairs. The petals were scarcely perceptible; but the filaments were distinctly visible, surmounted with white anthers. The pistils were not yet visible, but they became visible in the following month, when the anthers had begun also to assume a tinge of red. The ovary was not distinguishable in the earlier dissection; but it was distinguishable before the evolution of the bud.

Similar appearances may be seen by opening up the flower-buds of almost any plant, long before the time of their natural evolution. The *Mezereon* produces its flowers in the month of January or February. But if a bud is taken and dissected in the month of August preceding, the petals, the stamens, and the envelopes of the young fruit, may be all distinctly perceived. The Peach-tree produces its flowers in April. But if a bud is dissected in the month of February preceding, the whole of the parts of fructification may be perceived in miniature, wrapped up in the calyx by the overlapping of its divisions. The corolla is extremely small, but the stamens and pistil are very perceptible; and the pollen may even be discerned in the anthers.

If a bud producing both leaf and flower is taken Or both.

---

* Phys. des Arbres, liv. iii. chap. i.

and dissected in the foregoing manner, the rudiments of its future products may be also distinctly perceived long before the period of its evolution. Ledermuller is said to have dissected a bud of the Horse-chesnut, containing both leaf and flower, in the winter, of about the size of a Pea, in which, after removing the scales, he found four branch-leaves covering a flower-spike consisting of upwards of sixty florets. In the month of March 1810, I opened up a bud of the same plant which had not yet burst its scales. The scales, which were about fifteen or sixteen in number, being removed, were found to contain one pair of opposite leaves now laid bare, the divisions of which were closely matted together with a fine down. The leaves upon being opened were also found to contain within them a flower-spike, consisting of not less than a hundred florets closely crowded together, each enveloped by its downy calyx, which when opened discovered the corolla, stamens, and pistil, distinct; the rudiments of the future fruit being also discernible in the ovary.

The petals of the corolla before their evolution are wrapped up in the flower-bud like the young leaves of the plant in the leaf-bud; and are also found to exhibit similar varieties of involution, which seem to have been first observed and described by Grew in his Anatomy of Plants.*

---

* Anat. of Plants, book. i. chap. v.

SUBSECTION II.

Dissection of.

The Bulb.—Bulbs, which according to the distinctions instituted in the foregoing book are either radical or caulinary, exhibit in their external structure, or in a part of their internal structure that is easily detected, several distinct varieties, some being solid, some coated, and some scaly; but all protruding in the process of vegetation the stem, leaf, and flower, peculiar to their species.

Whether solid,

If the solid bud is taken and divided into two halves by a vertical or longitudinal section, it will be found to consist externally of a sort of fibrous or membranaceous envelope separable into two or more layers; and internally of a fine epidermis enclosing a firm but succulent pulp, in the centre of which are lodged the rudiments of the future plant, as in *Gladiolus communis* and *Colchicum autumnale*, in which the several parts of the flower may be distinctly perceived long before the period of their natural evolution.

Coated,

If the coated bulb is taken and dissected, it will be found to be composed of a succession of concentric layers somewhat resembling a number of hollow spheres gradually diminishing in size from the circumference to the centre, and enclosed within one another. The exterior layer consists sometimes of a fine and delicate membrane, as in the Onion; or of a thick and leathery coat, as in the Tulip, forming a sort of envelope to the bulb; and the interior layers, of a fine epidermis enveloping a succulent pulp from which they acquire a considerable thickness particularly towards the base, and form a sort of fleshy mass, being united by a viscid juice that exudes from their surface, as in the bulb of the Onion; or by transverse and vertical partitions, as in the bulb of the Snow-drop. The incipient plant is lodged in the centre of the nucleus, and is discoverable by dissection long before the period of its natural evolution, as in the case of the solid bulb. This is particularly well exemplified in the bulb of the Tulip, which if it is taken even in the beginning of January and cut up carefully into two halves in a line passing through its longitudinal axis, the petals, stamens, and pistil, and incipient stem, may be all distinctly perceived, small and delicate in their appearance, but complete in all their parts.

Or scaly.

If the scaly bulb is dissected, it will be found to consist externally of the base of the sheathing part of the root-leaves of the former year, transformed into the shape of scales by the decay of their upper portion, and distributed like the scales of the bud; and internally of the rudiments of the root-leaves of the following year, with the incipient stem and stem-leaves occupying the centre.

Whether radical,

But in the dissection of radical bulbs, of whatever species, there is generally to be discovered several small and incipient bulbs issuing from the main bulb, and situated for the most part upon the base; if in the solid bulb, between the envelope and nucleus; and if in the coated or scaly bulb, between the coats or scales. In their form they resemble buds, and, in the process of vegetation, are detached from the parent plant and converted into new individuals.

Or caulinary.

The caulinary bulb is alway a scaly bulb, resembling the bud in the structure of its scales and evolution of its contained parts; and differing from it merely in the circumstance of its detaching itself spontaneously from the parent plant, and forming a distinct individual.

SUBSECTION III.

The Propago.—The Propago, which is a simple gem peculiar to some genera of imperfect plants, and exemplified by Gærtner in the Lichens, consists of a small and pulpy mass forming a granule of no regular shape, sometimes naked, and sometimes covered with an envelope, which is a fine epidermis.

SUBSECTION IV.

The Gongylus.—The Gongylus, which is also a simple gem peculiar to some genera of imperfect plants, and exemplified by Gærtner in the Fuci, consists of a slightly indurated pulp moulded into a small and globular granule of a firm and solid contexture, and invested with an epidermis.

SECTION VI.

The Caudex.

Definition.

THE term Caudex, in its present application, is to be understood as including the whole mass or body both of the trunk and root, as distinct from the temporary parts of the plant, or parts already investigated; and as comprehending both the *caudex ascendens*, and *caudex descendens* of Linnæus, or the trunk and its divisions, with the root and its divisions.

Varieties of structure,

In opening up and dissecting the caudex, whether ascending or descending, the dissector will soon discover that its internal structure, like its external aspect or habit, is materially different in different tribes of plants. This was long ago pointed out by Grew in his Anatomy of Trunks, and well illustrated by plates. It was further illustrated by Plumier in his treatise on the Ferns of America, as well as also by Linnæus; and still more recently by Messrs. Daubenton and Defontaines, who have indeed investigated the subject with great ability; the former in a Memoir presented to the Academy of Sciences in 1790; and the latter in the first volume of the Memoirs of the National Institute, but who, by generalizing their notions perhaps somewhat too hastily, and without that full induction of particulars which the case requires, have been led to exhibit rather a defective view of the modes of vegetable organization; and to apply such as they have exemplified rather incorrectly to the different tribes of plants.

As exemplified in monocotyledonous and decotyledonous plants,

This remark alludes to the two different modes of internal structure, which they have indeed demonstrated and described in the most masterly manner in the above mentioned papers, and presumed, as it would appear, if not altogether to exhaust the subject, at least to correspond respectively to the two different divisions of plants known by the appellation of *Monocotyledonous* plants on the one hand, and *Dicotyledonous* plants on the other; the caudex of the latter being represented as composed of distinct, concentric, and divergent layers, decreasing in solidity from the centre to the circumference, and containing the pith in a canal; and the caudex of the former being represented as exhibiting no evident traces of concentric or divergent layers; but bundles, or assemblages, of large and woody fibres, decreasing in solidity from the circumference to the centre, and interspersed throughout a pith.*

Which do not exhaust the subject.

But the fact is, that the two modes of internal structure here specified do not uniformly and respectively pervade the two grand divisions of plants now in question to the exclusion of each other; there being many *dicotyledonous* plants whose mode of internal structure is precisely the same with that which is here described as peculiar to *monocotyledonous* plants, as may be exemplified in most herbs; although the converse of the proposition may not be true; so that if any general division arising from internal structure is adopted, it must be instituted on different grounds.

---

* Defon. Mem. de l'Instit. Nat. tome i.

And if the subject is understood to be exhausted, what are we to say of such genera as are furnished with more than two cotyledons? Defontaines says, indeed, that they are only dicotyledonous plants after all, but does not offer any satisfactory proof, which if he were even to produce, still there would remain the several tribes of plants that are confessedly destitute of cotyledons altogether, which would leave an additional class or division entirely unprovided for, even if we should not, with Dr. Smith, suppose the Date Palm, the very subject of Defontaines' description, to be itself *acotyledonous.*

But this additional class is altogether different in its organization from the other two, exhibiting neither the woody layers of the one, nor the woody fibres of the other; but consisting merely of a spongy, or leathery, and homogenous mass of pulp or slender fibres enveloped by an epidermis, as in the case of many of the imperfect plants; which cannot however be represented as exhibiting any very strict uniformity of structure throughout, but only such a similarity of mode as may justify an arrangement founded merely on generalities. And hence the ground of a much more comprehensive division of vegetables, as founded on the internal structure.

SUBSECTION I.

The Caudex an Homogeneous Mass.—The first general mode of the internal structure of the caudex is that in which an epidermis encloses merely an homogenous mass of pulp or slender fibre, that forms the principal body of the caudex, and becomes somewhat indurated with age, though not woody, without discovering any further variety of component parts. This is the simplest mode of internal structure existing among vegetables, as has been observed by M. Mirbel in his Anatomy of Plants, and exemplified in the lower orders of frondose and imperfect plants, particularly the *Algæ* and *Fungi*, so that any one may easily satisfy himself on the subject, as many plants of the above tribes are extremely common, such as *Lichen* and *Tremella* in the former, and *Boletus*, *Agaricus*, and *Clavaria* in the latter. (*Pl.* VIII. *Fig.* 12.)

As exemplified in the algæ and fungi.

Plants of this structure have seldom any distinct or conspicuous root; or if they have, it consists merely of a few small fibres which are themselves composed of an epidermis or bark containing a tough and stringy thread.

SUBSECTION II.

The Caudex an heterogenous mass.—The second general mode of internal structure is that in which an epidermis encloses a caudex, that consists of two or more substances, or assemblages of substances, totally heterogeneous in their character.

The Mass consisting of pulp and interspersed fibre.—A very common variety of this mode is that in which an epidermis or bark encloses a soft and pulpy mass, interspersed with a number of longitudinal nerves or fibres, or bundles of fibres, extending from the base to the apex, and disposed in a peculiarity of manner characteristic of a tribe or genus. This mode prevails chiefly in herbaceous and annual or biennial plants, and necessarily involves some considerable variety; the pulp being sometimes solid and sometimes tubular, and the fibres being, in both cases, sometimes scattered and sometimes contiguous, sometimes arranged irregularly and sometimes in a determinate order.

As exemplified in annuals and herbaceous plants.

As in aspidium filix-mas.

1. *The Pulp being solid.*—If the stipe of *Aspidium Filix-mas* (*Pl.* VIII. *Fig.* 13.) is taken and divided by a transverse section towards the base, it will be found to consist of an epidermis enclosing a solid pulp, and to exhibit upon the surface of the section, five circular spots of a darker colour than the rest, arranged in a line forming about three-fourths of the circumference of a circle, and concentric to the circumference of the stipe. These spots are the divided extremities of five bundles of longitudinal nerves, as may be rendered evident by opening up the stem longitudinally, when the several bundles will appear in the form

of strong threads, each surrounded with a proper bark or covering of a brown colour and membranaceous contexture, and extending throughout the whole length both of the stipe and rachis.

Pteris aquilina,

If the stipe of *Pteris aquilina* or Common Brake is taken, and divided by a transverse section towards the base, it will be found to consist of an epidermis or bark, enclosing a solid pulp; and to exhibit upon the surface of the section a number of clusters or circular spots, of a darker colour than the rest, but not so arranged as to be reducible to any very definite figure. Their aggregate appearance however, upon an oblique section has been thought by Linnæus to bear a resemblance to the eagle of the Roman standard, sufficiently correct to entitle the species to the trivial name of *aquilina*, though it cannot be said that the likeness is any thing very striking. But the transverse section exhibits a likeness that is perhaps more so, namely, that of an Oak-tree in full leaf; a likeness that has been recognized at least by the peasantry of this country, among whom it is designated by the name of *King Charles' Oak*.

And the date palm.

If the stipe or stem of the Date Palm is taken and divided by a transverse section, it will be found to consist of an epidermis enclosing a pulpy and solid mass; and to exhibit over the whole surface of the section a great number of black spots dispersed without any regular order upon a white ground, larger in the centre, and smaller in the circumference; but the largest not being more than the third of a line in diameter. These spots are the divided extremities of bundles of longitudinal fibres passing from the base to the summit of the stem, in a direction parallel to its axis, and separable by maceration.

This is the famous example adduced by Daubenton and Defontaines, in illustration of the structure of what are usually termed Monocotyledonous plants, to which order of plants, it seems, there are some botanists who believe that the Date Palm does not at all belong.* If this is the fact, which appears to be extremely doubtful, then the Date Palm is rather an unlucky example of the order of plants in question. But to whatever order it may belong in an arrangement founded on the character of the cotyledon, there can be no doubt with regard to its order, in an arrangement such as the present.

2. *The Pulp being tubular.*—When the pulp is tubular, the bundles of longitudinal fibres are generally arranged in a circular row either simple or compound, immediately under the bark; so as, in conjunction with the interspersed pulp, to form externally a fluted column, and internally a hollow cylinder, that is sometimes partly filled with a floccy or pith-like substance, and sometimes altogether empty.

As in hemlock.

If the stem of the Garden Parsnep or Common

---

* Smith's Inquiry, &c. Lin. Trans. ix.

Hemlock (*Pl.* VIII. *Fig.* 14.), which constitutes externally a fluted column, is taken and divided by a transverse section, it will be found to consist of an epidermis containing a hollow cylinder of united pulp and fibre, lined with a soft and spongy pith, which is itself tubular; and again lined with a fine and transparent membrane, consisting of a most intricate plexus of soft and delicate fibres, forming an ultimate cavity, which is sometimes partly filled up with a fine and cottony down, or with fine and transverse diaphragms resembling cobwebs.

But the circular row of bundles observable in the above plants, and others of a similar structure, is not the same in all. Sometimes it is simple, as in Hemlock; and sometimes it is compound, as in the Parsnep. In the former case it consists merely of a succession of individual bundles distributed in a circular row, so as to complete the cylinder. In the latter it consists of a succession of individual bundles, traversing the pulp in a direction from the circumference to the centre, as far as the pulp extends, and then returning from the centre to the circumference, after forming a fold, and so on till the cylinder is completed by a succession of folds.

It should be also added that the tubular stem does not always form one continued cylinder, except in some of the Agarics, but rather a succession of individual cylinders united to one another by joints that form transverse diaphragms, interrupting the continuity of the tube even though it is furnished with no pith, as in the Grasses.

Plants of this class are all furnished with a distinct and conspicuous root, the structure of which is often similar to that of the stem, as may be seen in the horizontal section of the Common Brake; in which some of the bundles are flattened and bent so as to form a section of a circle, the rest being placed irregularly around them. But though the stem of such plants is often tubular, yet the roots are not often tubular (though the root of Water Hemlock furnishes an exception), but wholly filled up either with pulp or pith contained within the cylinder of fibres, which the bark or epidermis externally invests.

SUBSECTION III.

The Mass consisting of Bark, Wood, and Pith.—A second variety of this mode is that in which a strong and often thick bark encloses a circular layer of longitudinal fibres, or several such circular and concentric layers, interwoven with thin transverse and divergent layers of pulp, so as to form a firm and compact cylinder, in the centre of which is lodged a pulp or pith. This mode is best exemplified in trees and shrubs (*Pl.* VIII. *Fig.* 13.), though it is also applicable to many plants whose texture is chiefly or almost wholly herbaceous, forming as it were the connecting link between such plants as are purely herbaceous on the one hand, and such as are purely woody on the other. In the latter case the wood is perfect; in the former case it is imperfect.

As in the stem of beet-root,

1. *The Wood being imperfect.*—If the root of the Beet is cut open by a transverse section it will be found to exhibit a most beautiful example of the union of the concentric and divergent layers, as enclosed within a bark, and enclosing a pith; and remaining at the same time wholly herbaceous. But the mature stem of the full grown plant approaches in part the consistence of wood, and points out its affinity to shrubs and trees.

Cabbage,

If the stem of the common Cabbage is cut open by a transverse section it will exhibit first—a bark; then an enclosed layer of a firm and compact texture approaching that of wood, and intersected with a multiplicity of divergent rays; and then a large and firm pulp or pith. The same structure pervades also the root, which is furnished indeed with but little pith, but exhibits the woody part in much greater perfection; the divergent rays, which are sections of divergent layers, being much larger, and the concentric layers being more in number. In some stages of its growth, the section exhibits divergent layers only, intersecting what seems to be a pulp; but in its state of decay the woody part separates naturally into a number of fine and concentric layers resembling lace; which appearance is still more aptly exemplified in the decaying root of the Artichoke, the lace-like texture of which is peculiarly beautiful and delicate.

And the bramble,

If the stem of the common Bramble or Burdock is taken and divided by a transverse section, it will be found to consist of an epidermis or bark, enclosing a cylindrical layer of pulp and interspersed fibre, approaching to the consistence of wood, and containing within it a firm and compact pith that occupies the centre.

In which the texture of the wood is yet herbaceous.

Such are some examples of plants exhibiting an affinity to herbs on the one hand, in their external aspect or habit; and to trees, on the other, in their internal structure and contexture; forming the connecting link that introduces us to the anatomy of plants that are purely woody, and known by the designation of shrubs and trees.

As in the oak or elder,

2. *The Wood being Perfect.*—If the caudex of a tree or shrub, such as the Oak or Elder, is taken and divided by a transverse section, it will be found to be composed of three evidently distinct parts—an outer, an intermediate, and a central part; each exhibiting an aspect or structure peculiar to itself.

The outer portion of the caudex is the bark, which in young subjects is of a flexible and leathery texture, as well as easily detached from the interior portion, at least in the spring. But in old subjects it is often highly indurated, approaching in its texture to wood, and frequently splitting into chinks and fissures, as may be seen in the aged trunks of the Elm and Fir. In the root it is said to be generally thicker than in the stem and branches, and of a dull and earthy colour, though affected a little by the soil in which it grows; but in the root of the Elm it is reddish; in that of the Berberry it is yellowish; and in that of the *Cytisus* of the Alps, it is black.

In young shoots and branches both from the stem and root, it may be distinguished into the three following parts: 1st, *An Epidermis,* or external pellicle; 2d, *A Parenchyma*, or soft and pulpy substance situated immediately under the epidermis, and constituting a sort of secondary integument; and 3dly, a number of *thin and concentric layers*, forming its interior and principal portion, and generally designated by the name of the cortical layers; but known also by the appellation of the *liber*. In the root the several layers are said by Du Hamel to be thicker than in the trunk; but I have not found any notable difference between them in this respect.

In which the wood is a firm and compact mass.

The intermediate portion of the caudex is the wood, which constitutes the great body of the full grown plant. In most plants it is whitish, as in the Ash and Fir; but in the stem of Lignum-vitæ and Logwood it is of a deep red; and in that of the *Laburnum* it is variegated, at least in aged subjects. In the full grown tree it is not wholly of the same density throughout, being hardest at the centre and softest at the circumference; which difference is so striking, that the outer and softest portion has been designated by the name of the *alburnum.*

If the transverse section of the wood is now minutely inspected it will be found to consist of an indefinite number of concentric layers of considerable, but not of equal thickness, intersected by a number of transverse layers diverging from the centre like the rays of a circle; which are often, but not with much propriety, denominated medullary rays, upon the supposition that they originate in the pith, a notion that is now exploded. I shall therefore designate them by the more appropriate term of the divergent layers, as being descriptive at least of their distribution and position. But the layers, whether concentric or divergent, that compose the intermediate portion of the caudex, are often designated also by the appellation of the ligneous layers, as constituting the mass of the wood, and in contra-distinction to the cortical layers, or layers constituting the bark.

The central portion of the caudex is the pith, which is a soft and spongy substance of a whitish colour, surrounded by the wood as by a tube; or rather by a cylindrical row of longitudinal fibres closely united together in the form of a tube, and investing it like a sheath; on account of which resemblance M. Mirbel denominates it the tubular sheath.* But as this term indicates no important property belonging to the sheath, and does not even aim at pointing out its use, it will perhaps be better to give it the appellation of the Medullary sheath, or the sheath investing the Pith.

In some plants the diameter of the pith is large in proportion to that of the stem, as in the Fig, Elder, and Sumach; while in others it is but very small, as in the Ash; and in others scarcely perceptible, as in the Oak and Elm. It is always most abundant in the young and tender shoot, of which, indeed, it constitutes originally the principal mass. But as the wood increases, the pith gradually diminishes, till in old and full grown trunks it totally disappears, and has its place occupied by wood. In the root it is always less abundant, and perhaps also more compact, than in the stem and branches, being discoverable only in the larger divisions, but not in the radicles or fibres; and disappearing also in the mature state of the plant. But in many roots, such as those of the Elm and Laburnum, it is not distinguishable even in the larger divisions themselves. It is distinguishable, however, in the root of herbaceous plants, and in the larger divisions of the root of the *Arbor-Vitæ*, Elder, and Berberry, in which last it is easily detected as being of a shade of colour considerably different from that of the rest of the caudex.

---

* Phys. Veg. vol. i. p. 186.

SUBSECTION IV.

General Remarks.—Such is the general outline of the structure of the caudex of herbaceous plants on the one hand, and of woody plants on the other, whether as ascending or descending. But the structure of the branches or divisions is the same. For they are not merely prolongations of a part of the caudex diverging from the centre, and extending beyond the circumference; but they are each a caudex in miniature, furnished with a pith, wood, or interwoven fibre and pulp, and bark, precisely as in the caudex itself. This has been rendered evident by Du Hamel in his *Physique des Arbres*, by the following illustration.*

If you take a horizontal section of a stem with two branches a little above the cleft, the appearance is that of two stems. If you take the section in the fork itself, you will then find in the centre two sets of concentric layers, corresponding respectively to the two branches, but enveloped by another set common to both, that forms the circumference of the stem. If you take the section still lower you will find the layers that correspond to the two branches diminishing in number, and the outer layers increasing, till at last the central layers disappear altogether. Thus the layers proper to each branch form in the original stem an inverted cone, of which the summit is at the centre, and the base at the fork or circumference. The subdivisions of the branch are formed in the same manner, and so also the divisions and subdivisions of the root, except in the extreme fibres, the production of the present year; which consist merely of a mass of pulp surrounded with a bark, and which seem in some degree to resemble the leaves of the *caudex ascendens*, as they are said to be renewed annually.

---

* Liv. i. chap. v.

SECTION VII.

Appendages.

THE Appendages of the Plant, whether conservative or reproductive, exhibit nothing in their structure that is at all essentially different from that of the organs that have been already described.

The tendrils, stipulæ, and ramenta, which are proper to the conservative organs, resemble the leaf, or leaf-stalk. The involucre, spathe, and bracte, which, together with the nectary, are proper to the flower, resemble the leaf, calyx, or corolla. And the appendages of the fruit, which have indeed been originally a part or appendage of the flower, together with the appendages of the seed, are all ultimately resolvable into membrane, pulp, or fibre.

Reducible also into membrane, pulp, and fibre.

Glands.

But the organs denominated glands, or included under the designation of pubescence, deserve to be somewhat more particularly noticed; not on account of any thing peculiar in their structure, which is reducible to one or other of the substances already named, and seems to be merely a partial prolongation of inflated pulp or epidermis; but because it has been doubted whether there are indeed any organs in vegetables analogous to the glands of the animal system, and consequently whether the term gland ought to be at all retained. But if the fluids absorbed by the root are modified and elaborated in the course of their progress through the plant, as there is every reason to believe they are, it is likely that this elaboration is partly effected by the instrumentality of glands. And as some of the substances so designated have been found to secrete a peculiar fluid, as in the case of Cruciform flowers, the name ought by all means to be retained.

Whether organs of secretion.

But the hairs constituting the external pubescence have been regarded by some phytologists as being also glands, though they have been regarded by others as being merely organs of excretion. It is at least certain that they contain in many cases a peculiar juice, which they have probably secreted. For they are often covered with a clammy or viscid substance, or terminated by a drop of transparent and odorous fluid, which exudes from them. In the Nettle they contain a pungent and corrosive fluid, which is lodged and discharged by pressure. But the most decisive observations or experiments on this subject are those of Deyeux. On the stem, leaves, and calyx of the *Cicer arietinum* he observed a number of small globules of water, which were most conspicuous about mid-day, and which when wiped off appeared again in the course of some hours. They were formed at the extremity of the hairs, and were again reproduced even when the summit was cut off, though somewhat more slowly than in those that were entire. They were also again reproduced even when the one half of the hair was cut off, though still more slowly than before. But when the hair was cut off at the base they were no longer reproduced at all. Whence Deyeux concluded that they are also organs of secretion.*

CHAPTER II.

COMPOSITE ORGANS.

Enumeration.

FROM the previous analysis of the plant, the decomposite organs have been found to be reducible, in the first place, to one or other of the several following substances: namely, epidermis, pulp, pith, cortical layers, ligneous layers, vegetable fibre; which now remain to be farther analyzed, under the title of Composite Organs, as being still compound, with a view to reach the ultimate and elementary organs of the vegetable subject.

---

* Jour. de Phys. No. xlvi. p. 365.

SECTION I.

Of the Structure of the Vegetable Epidermis.

The Epidermis of the Vegetable, which, from its resemblance to that of the animal, has been designated by the same name, is the external envelope or integument of the plant, extending over the whole surface, and covering the root, stem, branches, leaves, flower, and fruit, with their appendages; the summit of the pistil only excepted. But although it is extended over the whole surface of the plant, it is not of equal consistence throughout. In the root and trunk it is a tough and leathery membrane, or it is a crust of considerable thickness, forming a notable portion of the bark, and assuming some peculiar shade of colour which it seems to acquire from age; while in the leaves, flowers, and tender shoots it is a fine, colourless, and transparent film, not thicker than a cobweb. But its want of colour is discoverable only when detached; for, when adherent, it is always tinged with some peculiar shade, which it borrows from the parts immediately beneath it. Hence the green colour so prevalent in the leaf and tender shoot, which the epidermis merely transmits, and the beautiful variety of lines displayed in flowers and fruits. And yet the colour is sometimes inherent even in the epidermis itself, as may be seen by inspecting that of the lower part of the petals of *Crocus vernus*.

In the permanent parts of woody and perennial plants the old epidermis often disengages itself spontaneously, as in the Currant, Birch, and Plane-tree, in which it seems to be undergoing a continual waste and repair; and in such parts it is again regenerated, even though destroyed by accident. But in herbaceous plants, and in the leaf, flower, and fruit of other plants, it never disengages itself spontaneously, and is never again regenerated if once destroyed.

Du Hamel, who seems to have been the first to institute any very minute inquiry into the structure of the vegetable epidermis, describes it as being formed of a multiplicity of fine and delicate fibres placed in a parallel direction, and inosculating at regular intervals, or united by means of small and lateral fibres, so as to constitute a net-work, the meshes of which are filled up with a thin and transparent pellicle; thus forming a membrane that consists either of a simple and individual layer, as in the epidermis of most plants, or of several distinct and separate or separable layers, as in that of the Paper Birch; in which he counted six or more. He studied it chiefly as it occurs in the bark of trees, and adds that it was sometimes to be met with so very compact, as to exhibit no traces of net-work, even under the microscope, but merely a smooth and uniform surface.*

---

* Phys. des Arbres, liv. i. chap. ii.

Saussure the elder, whose observations on the epidermis are the next in order of time, and who studied it chiefly in the leaves and petals of Jessamine and Fox-glove, describes it as constituting a bark composed of two layers; the interior layer consisting of a net-work, which he calls the cortical net-work, interspersed with a multiplicity of what he calls cortical glands; and the exterior layer consisting of a fine and transparent membrane which he regards as the true epidermis, capable of being partly detached, but totally destitute of organization. The glands he describes as being small and oblong or circular bodies, encompassed by a fine thread or fibre, not immediately attached to them, but separated by a narrow interval, and communicating with the cortical net-work, as well as being in some plants discoverable with the assistance of a good glass, even through the exterior layer of the epidermis, under the appearance of white and transparent spots. Their mean diameter was about the eightieth part of a line. They were more numerous on the upper surface than on the under surface of the leaf; but were not to be met with in the epidermis of the petals, which seemed however to be furnished with organs somewhat analogous; namely, small vesicles of a conical form, emerging from the surface, and perhaps giving colour to the corolla.*

Hedwig, who was led to the investigation of the subject, from a wish to repeat some experiments of M. Von Gleichen upon the epidermis of Common Polypody and Wall-Rue, in which he thought he had detected the stamens or anthers of Ferns, instituted his observations upon the epidermis of the same plant, and met with the same appearances. But as he met with them in all parts of the plant indiscriminately, as well as in a variety of plants with conspicuous flowers, he began to suspect that M. Gleichen's opinion concerning them could not be correct; though he admitted them to be a set of peculiar organs, of which M. Gleichen was to be regarded as the original discoverer. It is plain, however, that the organs here alluded to are nothing more than the cortical glands of Saussure; with whose discoveries Hedwig does not appear to have been yet acquainted.

---

* Observ. sur l'Ecorce de Feuilles, &c.

But the organs in question which Saussure regarded as glands, and M. Von Gleichen as the anthers of Ferns, Hedwig regards as being merely pores, or apertures, perforating the pellicle that forms the epidermis. They are contained within a peculiar area, which is sometimes round, sometimes oval, and sometimes rhomboidal. They are themselves generally oblong, though they are often so much shrunk or contracted as to change their form. They do not extend so far as to touch the margin of the area; but in the Grasses they are longer than in other plants. In their longitudinal direction they follow for the most part the longitudinal direction of the leaf, together with the areas they occupy, which communicate with one another by means of certain ducts or vessels originating in their circumference, and forming part of the general net-work, which is composed of two distinct but adherent laminæ. Finally, they are regarded as being organs of perspiration; and their peculiar areas, which consist also of two distinct but not adherent laminæ, are regarded as forming receptacles for perspirable matter. The number of them discoverable in the extent of a square line amounts to about 577.*

Comparetti.

Comparetti, Professor of Botany at Padua, describes the epidermis as consisting of a net-work of fibres ascending in an oblique direction, and forming hexagonal meshes of various sizes and positions, but of which the vertical sides are the longest; the area of the meshes being occupied by opaque or transparent points, of an oval or roundish figure, that seem to be somewhat inflated, as if filled up with air or water. Upon a more minute inspection the points seemed to be composed of three small fibres, two of which were lateral, and one central. If the bubble contained within them escaped or was dispersed, the area became depressed at the circumference, but transparent at the centre, which was still however occupied by a small black point. His observations were made chiefly on the epidermis of succulent plants, such as the Lily, Poppy, Spurge, and plants with compound flowers, in which the same organization was perceptible, except that in the calyx, corolla, stamens, and pistils, the points of the areas were fewer; and the net-work was composed of layers that might be separated, the interior layer being thick, opaque, and succulent, and often coloured, as in Endive, Celandine, and *Phytolacca;* in which it was respectively white, yellow, and red.*

---

* Tracts relative to Botany, London, 1805.

Bauer.

Mr. Francis Bauer, of Kew, who has studied the structure of the epidermis with much attention, and illustrated his observations with elegant drawings of the portions inspected, seems to be somewhat sceptical with regard to the existence of the ducts or vessels of Hedwig, by which the peculiar areas of the net-work have been thought to communicate with one another. His observations were made chiefly upon the epidermis of *Begonia nitida, Crassula umbellata, Orchis mascula,* and several species of *Dianthus.* But the most singular structure he specifies is that which occurs in the cuticle of *Doryanthes hastata Corrêa,* a new liliaceous plant from New Holland, and of a species of *Hæmanthus,* the epidermis of which, being of a thicker texture than ordinary, seems to be composed of two or three stories of cells laid one above another, and exhibiting in their aggregate aspect a resemblance to that of an honey-comb. Each of the orbicular receptacles communicates with that immediately beneath it, but no farther communication is to be seen. What appear to be ducts or vessels as described by Saussure and Hedwig are, in the opinion of Mr. Bauer, nothing more than the edges of the dissepiments of the cells of the cuticle.*

---

* Senebier, Phys. Veg.

Such then is the result of the observations of the most distinguished botanical anatomists, who have directed their attention to the general structure of the epidermis. Their descriptions do not indeed tally quite so completely as could be wished: but an exact coincidence was not to be expected in the description of an organ that differs so much in different species of plants, and even in different parts of the same plant; unless the observations of each investigator had been confined to the same species, and to the same part. And even then the coincidence would have been but partial, as being affected by the age of the plant, or season of observation.

But it is to be remarked that the first four of the preceding accounts agree in all the leading points of description as far as they go; namely, in representing the epidermis as composed of a net-work of fibres consisting of two or more layers, and the meshes in being filled up with a fine pellicle, in which there is often discoverable a peculiar area connected with the general net-work, by means of lateral ducts or fibres; and exhibiting in the centre the appearance of minute glands, or pores, or inflated points; with which account, if Mr. Bauer's description does not agree, it can only be because the specimens he examined were actually different in their structure; as his accuracy of observation, and skill in botanical drawing, are too well known to stand in need of any comment. It must be admitted, however, that the epidermis of the majority of plants is much better described by the net-work of Saussure and Hedwig, than by the cells of Mr. Bauer; and that the fibres forming the meshes seem to be something more than mere dissepiments.

---

* Tracts relative to Botany, London, 1805.

The above remark does not however lessen the value of the observations of Mr. Bauer; as it is often as important to know the exception as the rule itself. And it is likely that farther inquiries will produce farther exceptions. The epidermis of the petals of the Snow-drop, *Galanthus nivalis*, coincides pretty nearly in appearance with that of *Doryanthes* and *Hæmanthus*, exhibiting what may be aptly enough compared to an assemblage of hexagonal cells; if not rather to the clusters of bubbles generated upon the surface of liquors in a state of fermentation, according to a similitude of Grew's upon a different subject.

Its aspect in crocus vernus.

But the epidermis seems to me to present, in some cases, an appearance to which no one of the foregoing descriptions or similitudes will correctly apply; and to exhibit a peculiarity of structure that does not appear to have been hitherto taken notice of. The epidermis of the inside of the petals of *Crocus vernus,* when placed under the microscope, does not present the appearance of a net-work, nor of an assemblage of cells, nor of the clusters of bubbles that form on the surface of liquor in a state of fermentation ; but rather that of a thin and individual layer of parallel and tangent reeds of unequal lengths, interspersed with multitudes of minute and shining points, and resembling a front view of the false pipes of an organ. Hence the structure of the epidermis is found to be characterized by the same sort of variety of modification, as the structure of the other parts of the plant.

With regard to the peculiar areas interspersed throughout the network of the leaves, together with their central appearances, and ducts of communication with the fibres constituting the meshes, the description of Hedwig is undoubtedly the most correct, as may be seen by inspecting with a good microscope the epidermis of the leaf of the Tulip or Hyacinth, or even of the common Lettuce or Cabbage of the garden; which I specify merely as being easily procured, and exhibiting, at the same time, the appearances distinctly.

The observations of Hedwig were made chiefly on the cuticle of the seed lobes of *Perilla ocymoides,* and *Cheiranthus incanus;* on the leaf and calyx, or corolla, of *Lilium bulbiferum;* and on the leaf of *Zea Mays* or Indian Corn. But one of the best of all leaves for a beginner to commence his observations upon is, perhaps, that of common Sorrel, *Rumex Acetosa*, of which the cuticle is so easily detached from the pulp that it may be obtained in large portions, merely by tearing the leaf in two, either in a transverse or longitudinal direction.

The longitudinal direction of the fibres and meshes of the net-work forming the basis of the epidermis is, as represented by Hedwig and Comparetti, generally verticle, or at least it follows the longitudinal direction of the plant. But although this is the rule, it has, like most other rules, its exceptions; as may be exemplified in the epidermis of the stem of the Currant and Cherry-tree, in which the longitudinal direction of the fibres and meshes is not vertical but horizontal, extending in a line that encircles the body of the plant, and gives to the epidermis a tenacity that is greatest in the vertical direction of the stem.

According to all of the foregoing descriptions the epidermis is represented as consisting of at least two if not more layers, which, in the stem of many plants, are very easily distinguished, particularly in that of the Paper Birch as exemplified by Du Hamel. The same thing may be also exemplified in the stem or branches of the Currant, *Ribes rubrum;* the outer layer of the epidermis of which, after acquiring from age a tinge of brown, splits into a number of fragments that spontaneously detach themselves to make way for a new layer, which on its first exposure to the air is of a fine and delicate green. If this layer is now stripped off, it will be found to invest one or two more which are yet, indeed, colourless and imbedded in pulp, being only in a state of preparation for future exposure, when the layer that is now exterior shall have detached itself in its turn.

The above should, perhaps, be regarded as a succession of individual cuticles, consisting each of a single layer, which their regular and consecutive detachment seems to indicate, rather than as an individual cuticle consisting of several layers; though there are cases in which several layers are obviously incorporated so as to form in the aggregate only an individual epidermis. Perhaps one of the best examples of an epidermis consisting of several layers, is that of the epidermis of the interior and sheathing part of the leaf of *Iris Pseudacorus* or Yellow Iris, of which if you detach several portions, some will be found to consist of more and some of fewer layers; and some apparently of only one layer of net-work, either because the epidermis is so constituted in different parts of the leaf according to their distance from the base, or because the layers have been forcibly separated in the act of stripping them off. In the portion apparently consisting of only one layer, the degree of transparency is greater, and the hexagonal meshes of the net-work are distinctly marked; but in the portion consisting of more than one layer, the degree of transparency is less, and the net-work confused and indistinct; because the epidermis is now thicker, and because the meshes of the several layers do not exactly coincide. The same thing may be exemplified in the epidermis of the Apple, of which the layers are two in number; the exterior layer being thin and transparent, and the interior layer being more succulent and tender, and tinged with a peculiar shade giving colour to the fruit.

But still the ultimate and unorganized pellicle of Saussure remains undetected, of the existence of which I have never yet been able to satisfy myself thoroughly. I have observed, indeed, though very rarely, in the epidermis of the leaf of the Honeysuckle *Lonicera Periclymenum*, a small portion of external pellicle of greater extent than the area of the meshes, in which no vestige of meshes was to be found, and which seemed, like Saussure's outer pellicle or true epidermis, to be totally destitute of organization. But whether this is to be regarded as a sufficient proof of an exterior pellicle distinct from the meshes, or whether the meshes whose area it had originally filled up might not have been obliterated merely from accident, seems to be somewhat doubtful. The appearance would have been the same in either case; so that unless the pellicle and network could be detached to some considerable extent, and exhibited separately, the proof must still be regarded as incomplete. Hedwig, whose dexterity in experiments of this kind was certainly not inferior to Saussure's, admits, as has been already seen, the existence of two distinct lamina in the net-work of the epidermis, which, however, he acknowledges he was never able to separate; but does not represent the exterior pellicle as being destitute of organization.

But whether the exterior and unorganized pellicle of Saussure exists or not, the accuracy of his observations upon the whole will still entitle them to the regard of the botanical anatomist, who will be able to judge of the fidelity of his representations by comparing a few of them with the original. Particularly, let him consult the case in which he distinguishes the structure of the epidermis of the petals from that of the leaf, as exemplified in the epidermis of the Pink and Pansy, to which there may be added, as affording also a good example, the epidermis of the inner surface of the petals of *Cocus vernus,* whose multitudes of minute and shining points, certainly resemble more the emerging vesicles of Saussure than the pores of Hedwig.

SECTION II.

The Pulp.

The Pulp is a soft and juicy substance, constituting the principal mass of succulent plants, and a notable proportion of many parts even of woody plants. It constitutes the principal mass of many of the *Fungi* and *Fuci*, and of herbaceous plants in general, as may be seen by dividing the frond or stem, either in a longitudinal or transverse direction; as well as of the seed-lobes and of succulent fruits, of which any one may easily satisfy himself by cutting up a Bean or Apple from the stalk or tree. It is also particularly conspicuous in the leaf and flower, with their foot-stalks when stripped off the epidermis. And even in the stem of woody plants it is not altogether wanting, although it is cognizable only in the bark of the young and tender parts, at least as a separate organ, where it constitutes a thin layer immediately under the epidermis, and forms a sort of secondary integument to the plant, known among botanists by the name of the cellular integument. But this integument seems to me to be, like the secondary integument of the Apple, merely an internal layer of the epidermis, or a distinct and separate epidermis in an incipient state rather than a true and proper pulp. In herbs and succulent plants, and in leaves and fruits in general, if it happens to be destroyed or devoured by insects, it is, like the epidermis in the same circumstances, not again regenerated. But in the bark of trees and shrubs it is again regenerated after some exfoliation even when destroyed by accident, without leaving any scar or trace of a solution of continuity.* In the leaves its colour is generally green, and in the seed-lobes white; while in flowers and fruit it assumes almost all varieties of shade whatever, according to the species of plant, or circumstances in which it is placed. When viewed without the microscope its appearance is that of an assemblage of small and minute granules imbedded in a soft and glutinous substance, as in the greater part of leaves and succulent fruits, in which last the fracture often presents an appearance resembling that of a piece of loaf sugar, as in the case of the Apple and Pear. But when inspected minutely with a good glass its structure is found to be very different.

---

* Seneb. Phys. Veget. vol. i. p. 177.

Its appearance under the microscope.

As described by Malpighi and Grew.

The first vegetable anatomists who investigated the structure of the pulp were Malpighi and Grew. The former describes it minutely, and compares it to an assemblage of inflated threads or bladders; the latter describes it under the appellation of the Parenchyma, and compares it to the bubbles formed upon the surface of liquor in a state of fermentation. Having examined it chiefly as it exists in the seed and infant plant, he made a calculation, by which it appeared to him to form at an average three fiftieths of the plumelet, five seventieths of the radicle, and three fourths of the cotyledons, though it is in some species more, and in some less.

By Du Hamel.

Du Hamel describes it under the appellation of the cellular tissue, I believe, and represents it as consisting of a number of longitudinal fibres diverging and uniting again continually, and crossing one another in all directions, sometimes interspersed with small and granular, or bladder-like substances occupying the interstices, and sometimes not; but of whose existence he began at last to be altogether in doubt. His observations were chiefly made on branches of the Lime-tree macerated in water. But as the long continued maceration to which the branches were exposed, must have less or more disorganized the structure of the pulp contained in them, he could not have inspected it in a perfect state.

Saussure,

Saussure investigated its structure in the leaves of the Bean and Periwinkle, in which he describes it as composed of large and transparent fibres successively inflated and contracted, and repeatedly inosculating, so as to resemble strings of contiguous vesicles forming a net-work. The contraction was observed in the middle of the sides of the meshes, and the inflation at the point of union.*

Comparetti,

One of the most distinct descriptions of this organ that has yet been given is that of Comparetti, who investigated its structure in the leaves of the Aloë, Houseleek, and several other succulent plants, in which it appeared to him to consist of an extremely fine net-work interspersed with small and glandular grains, enveloped in a green and glutinous substance and exhibiting an apparatus of vesicles. In the leaf of Purslain the granules seemed to be accompanied with small and transparent hairs, and the area of the meshes to be again traversed by fine threads forming a secondary net-work. On a transverse section of the leaf of the Aloë it seemed as if composed of a number of layers of little bladders, and on a longitudinal section the appearance was nearly the same. The figure of the cells was hexagonal with unequal sides, and their colour green, but of a deeper shade towards the surface of the leaf. In the calyx of the Sunflower a number of small fibres were found traversing the cellular substance which seemed to be intersected and bound together by others crossing them in a horizontal direction. The petals, stamens, and pistil, of the Lily exhibited a similar appearance, which was not, however, upon the whole very common.*

---

* Observ. sur l'Ecorce, p. 43.

And Mirbel,

But M. Mirbel, the latest author, as I believe, who has published any thing important on the subject, and who treats of it under the appellation of the Cellular tissue, presents us with a description of it considerably different from the foregoing. His observations were chiefly made upon it as it occurs in the Elder, as exhibiting the parts on a larger scale than most others plants. A section of the Cellular tissue or integument, whether vertical or transverse, presented the appearance of an assemblage of hexagonal cells resembling the cells of the Bee, each side being common to two cells, and the whole arranged with the most perfect symmetry. But if the cells happened to be compressed by any foreign force, the hexagon then assumed an elongated appearance. The partitions of the cells were found to be extremely thin and transparent, and their organization too fine to be distinguished even by the highest magnifiers. But they were generally perforated with holes or pores, whose diameters seemed to be less than the three hundredth part of a line, forming the medium of communication between the different cells, and bordered with a sort of small and glandular ring. The whole of the tissue was extremely delicate, but particularly in the several parts of the flower—the petals, stamens, and pistils, where the slightest touch stained it, and the slightest pressure destroyed it. It was also speedily destroyed by maceration in water. If the cells happened to be empty it was transparent and colourless, but if filled with juice it was generally green, though sometimes brown, yellow, or red, communicating its acquired colour to the epidermis, whether in the leaves, petals, or other parts of the plant.*

---

* Seneb. Phys. Veget.

Such are the accounts of the most distinguished vegetable anatomists upon the subject of the structure of the pulp. Their descriptions, as in the case of the epidermis, do not indeed exactly correspond. But the reason is sufficiently obvious. They did not all study it in the same state, nor even in its most perfect state—namely, that of complete insulation, as in the pulp of fruits; but rather in a state of intermixture with other parts, by which its natural structure is always somewhat affected. Its structure is, however, pretty fairly represented in one or other of the above descriptions in almost all its different aspects, but the description which I have found to be the most accurate and the most generally applicable, is that of M. Mirbel, in which he compares it to clusters of small and hexagonal cells or bladders containing for the most part a coloured juice, and formed apparently of the foldings and doublings of a fine and delicate membrane, in which no traces of organization are to be distinguished.

---

* Traité d'Anat. et de Phys. Veget. vol. i. p. 56.

Who divides it into herbaceous tissue and parenchyma.

But M. Mirbel, in the detail of his investigations, institutes also the following distinctions: In the trunk of what are called dicotyledonous plants, he regards the pulp, or to use his own appellation the Cellular tissue, as consisting of two distinct portions, which he designates by the respective appellations of the Herbaceous tissue, and the Parenchyma. The former is the exterior portion of the cellular tissue, of which the cells always contain a resinous and coloured juice, that communicates its peculiar tinge to the epidermis. The latter is the interior portion of the tissue, composed also of cells, but differing from those of the herbaceous tissue in containing only a watery juice without colour, because it has not been exposed to the action of the light, though in the calyx and fruit this watery juice is said to be also often coloured. But this is surely the setting up of a distinction without any very essential difference; for the structure is the same in both. And if the juice is in the one case resinous and in the other watery, may it not be accounted for like the colour, from the circumstance of accidental situation? But the character of the want of colour, on which great stress appears to have been laid, is in effect entirely done away as a ground of distinction; because the juice of the parenchyma is, as it seems, often coloured also like that of the herbaceous tissue itself, at least in the more tender parts of the plant. The distinction is therefore altogether destitute of utility. And if it is recollected that M. Mirbel employs the term parenchyma to denote also the pulp, or according to his own appellation the cellular tissue of the leaf, which is both colourless and resinous, it will appear to be besides destitute of propriety.

Though its real parts are merely an apparatus of vesicles and a contained juice.

But in the description of the vegetable pulp, the only distinction necessary to be made is that by which it is divided into two parts—namely an apparatus of hexagonal cells or vesicles, and a contained juice whether colourless or coloured—the union of which substances forms a true pulp. But as the cells may still remain, though emptied of their original juice, and constituting no longer a pulp, it seems necessary to precision both of idea and language, to designate each of the component parts of the pulp by an appropriate term, as we shall thus avoid the inconsistency by which the

PUBLIC LIBRARY OF THE UNIVERSITY

same term is made to signify at one time the empty cells only, and at another, both the cells and juice. To the former I shall therefore confine the appellation of *Cellular Membrane or Tissue ;* and to the latter that of *Parenchyma ;* in which respective acceptations these terms shall be employed throughout the following part of the work.

SECTION III.

The Pith.

Always central.

THE pith, as has been already shown, is a soft and spongy, but often succulent substance, occupying the centre of the root, stem, and branches, and extending in the direction of their longitudinal axis, in which it is enclosed as in a tube. In most plants it is close and compact without any apparent solution of continuity, as in the Willow and Poplar ; but in others it is loose and interrupted, as in the Walnut and Thistle; in the former of which it may be compared to a close and continued succession of transverse plates intersecting the central tube of wood; and in the latter, to a number of fine and membranaceous diaphragms placed at irregular intervals throughout the hollow cylinder of the stem, which occasionally burst open in the middle, and form a succession of rings. Sometimes it forms merely a fine and delicate film, of a smooth and brilliant appearance, lining the interior of the tube, as in the stem of common Hemlock. In the young shoot or plant it is green, changing to a bright white with age; but in the mature parts of the Walnut-tree it is brown, in the Berberry it is yellow, and in the root of *Calamus aromaticus* it is red.

Similar in structure to the pulp.

The structure of the pith is precisely similar to that of the pulp, being composed of an assemblage of hexagonal cells containing a watery and colourless juice, or of cellular tissue and a parenchyma. The pith of the Elder is well calculated for the purpose of microscopic inspection, as existing in great abundance, and exhibiting the figure of the cells on a large scale; though it does not always follow that plants which have the most pith have the largest cells. But the cells of the centre are larger than those of the circumference, where they are generally somewhat compressed, as may be seen by placing under the microscope a thin slice taken from the horizontal section of the pith of almost any plant. But it is only in the young and tender shoots or plants that the cells are filled with a fluid; for in the aged trunks and branches the parenchyma has escaped, and the cells are left empty.

Why designated by a proper name.

But if the structure of the pith is so precisely similar to that of the pulp, why, it may be asked, is it to be designated by a different name? Perhaps the central and insular situation which the pith always occupies is a sufficient reason. But the texture of the membrane composing the cells of the pith seems to be besides essentially different from that of the membrane composing the cells of the pulp; the former being evidently of a much more elastic nature than the latter, as well as much more capable of resisting the action of water, when emptied of the parenchyma, as may be seen by comparing them in their empty state. The juiceless pith of the Elder or Bulrush is a good example of the one; and the withered pulp, or cellular integument of the Lime-tree, is a good example of the other.

But although the pith has been described as insulated and unmixed with any other organ, it is not always entirely so. For it is occasionally to be found interspersed with longitudinal fibres passing throughout its whole extent, as may be seen in the older branches of the Elder, or even in the annual shoot in the course of the winter. In this case they are easily distinguished by their colour, which is a sort of rusty brown, while that of the pith is white, in the surface of which they lay imbedded. Perhaps this is the commencement of the process by which the pith is finally obliterated or converted into wood; and the origin of the circular row of longitudinal fibres, known by the appellation of the Medullary Sheath.

SECTION IV.

The Cortical Layers.

Their situation, size, and number.

THE cortical layers, or interior and concentric layers constituting the mass of the bark, are situated immediately under the cellular integument where such integument exists, and where not, immediately under the epidermis; or they are themselves external. They are distinguishable chiefly in the bark of woody plants, but particularly in that of the Lime-tree, in which they are easily separated by maceration or exposure to the weather, and in which you may readily count a dozen or more in a branch or trunk of any considerable size. They have been thought to correspond in number to the years of the plant's growth: but this opinion is not confirmed by accurate observation. They are more numerous, however, in the trunk than in the branches, which shows that their number is at least in proportion to the age of the plant, if not exactly corresponding to the number of years. They are also thicker in feeble plants than in vigorous and luxuriant plants of the same species, and in the individual plant they are thicker in the root than in the trunk.*

Texture.

The outer layers are coarse and loose in their texture, exhibiting individually a conspicuous and considerably indurated but very irregular net-work, composed of bundles of longitudinal fibres not ascending the stem directly, but winding more or less around the axis of the plant. Du Hamel describes it by saying that one or more of the fibres, originally composing a bundle, quits it, and diverges towards another bundle which it joins, but from which it again separates to join the bundles it had originally quitted; or it unites itself to other diverging fibres which it meets on the way, and so forms a new bundle. But the intersections of the fibres do not always take place in the same way in all plants, so that the net-work peculiar to one species is often very different from that of another. This may be seen by comparing together the net-work of the barks of the Oak and Elm, or of almost any other plants of different genera.

---

* Physique des Arbres, liv. iv. chap. iii.

Aggregate aspect.

As the layers recede from the circumference, the net-work which they form is finer, though still very irregular, and their texture more compact. But although the net-work is still irregular, yet the meshes of the different layers often correspond, forming an aperture that extends as far as the meshes coincide, but diminishing in size as it penetrates towards the centre, owing to the decreasing size of the meshes, and forming, according to the illustration of Du Hamel, a pyramid, of which the exterior mesh is the base. In the trunk of aged trees, such as the Oak and Elm, the apertures thus formed widen into large gaps and chinks, exhibiting still in their distribution the rough traces of the net-work of the original layer, now laid bare by the decay of the epidermis and cellular integument. But in the bark of young trees, or of the young parts of aged trees, the apertures formed by the coincidence of the meshes are not left empty but are occupied by a pulp somewhat compressed, which traverses the longitudinal fibres, and binds and cements them together. The cortical layers therefore are composed of two elementary parts—bundles of longitudinal fibres constituting a net-work—and a mass of pulp, more or less indurated, filling up the meshes.

Constituent parts.

The inner layers are soft, smooth, and flexible, and capable of subdivision till reduced to an absolute film, but not always exhibiting a conspicuous net-work, at least till macerated in water, or exposed to the action of the atmosphere, which decomposes and detaches the pulp or cellular tissue without affecting the longitudinal fibre.

Liber.

The innermost of the layers is denominated the Liber, the Latin term for a book, from its having been used by the ancients to write on before the invention of paper. It is the finest and most delicate of them all, and often most beautifully reticulated. But the Liber of *Daphne Lagetto* is remarkable beyond that of all other plants for the beauty and delicacy of its net-work, which is not inferior to that of the finest lace, and at the same time so very soft and flexible that in countries in which the tree is a native the lace of the Liber is often made to supply the place of a neckcloth.*

Anomalies.

But the layers of the bark do not always invariably constitute a net-work such as has now been

---

* Sloane, History of Jamaica, vol. ii. p. 22.

HALLIDIE LIBRARY OF THE UNIVERSITY

described. The bark of the Fir-tree displays no net-work; the Liber being merely a thick layer of parallel and contiguous threads, that seem to be composed of a succession of oblong and united vessels, and closely cemented together by a glutinous parenchyma; and the outer layers being merely thick plates of indurated pulp separated by a thin membrane that forms an epidermis to each.

If the cortical layers are injured or destroyed by accident the part destroyed is again regenerated, and the wound healed up without a scar. But if the wound penetrates beyond the Liber the part destroyed is no longer regenerated. Or if a tree is bent so as to break part of the cortical fibres, and then propped up in its former position, the fractured fibres will again unite. Or if a portion of the stem is entirely decorticated and covered with a piece of bark, even from another tree, the two different barks will unite. Hence the practicability of ascertaining how far the Liber extends. And hence also the origin of grafting, which is always effected by a union of the Liber of the graft and stock.

SECTION V.

The Ligneous Layers.

Of two sorts.

THE ligneous layers, or layers constituting the wood, occupy the intermediate portion of the stem between the bark and pith; and are distinguishable into two different sorts—concentric layers, and divergent layers,

SUBSECTION I.

Concentric Layers.—The concentric layers (*Pl.* VIII. *Fig.* 13.), which constitute by far the greater part of the mass of the wood, are sufficiently conspicuous for the purpose of exemplification on the surface of a horizontal section of most trunks or branches, as on that of the Oak and Elm, particularly after being some time exposed to the weather. But in some trunks, as in that of the *Laburnum*, they are marked even by a diversity of colour. Like the concentric layers of the bark they have been supposed to correspond in number to the years of the plant's growth. But the supposition seems to be here equally unconfirmed by accurate observation, though their number is no doubt in proportion to the age of the plant; as the trunk is always found to contain more than the branches. But it has not been by any means proved that there is only one layer formed in the course of a year. On the contrary Du Hamel has shown that a tree of twenty years old has not always twenty distinct layers; and that a tree of ten years old has sometimes more then twelve.

Discoverable on a horizontal section.

Indicate the age of the plant.

But though they are generally described as being concentric, they are not always strictly so. For they are often found to extend more on the one side of the axis of the stem or branch, than on the other. Some authors say the excess is on the north side, but others say it is on the south side. The

Are often irregular in shape.

former account for it by telling us it is because the north side is sheltered from the sun; and the latter by telling us it is because the south side is sheltered from the cold; and thus from the operation of contrary causes alleging the same effect, which has been also thought to be sufficiently striking and uniform to serve as a sort of compass, by which the bewildered traveller might safely steer his course, even in the recesses of the most extensive forest. But if this were even the fact, it would certainly prove to be one of the most incommodious compasses that was ever invented. For if the traveller must undergo the labour of cutting down a tree every time he may want to know his bearings, it is to be believed he will soon become tired of his instrument of observation.

But Duhamel has exposed the futility of this notion, by showing that the excess is sometimes on the one side of the axis, and sometimes on the other, according to the accidental situation of the great roots and branches; a thick root or branch producing a proportionably thick layer of wood on the side of the stem from which it issues. The layers are indeed sometimes more in number on the one side than on the other, as well as thicker. But this is the exception, and not the rule. They are thickest however on the side on which they are fewest, though not of the same thickness throughout. Duhamel after counting twenty layers on the one side of the transverse section of the trunk of an Oak, found only fourteen on the other. But the fourteen exceeded the twenty in thickness by one fourth part.* They are also generally thicker in the root than in the stem and branches, as has been already remarked with regard to the layers of the bark.

And always unequal in density.

But the layers thus discoverable on the horizontal section of the trunk are not all of an equal consistency throughout, there being an evident diminution in their degree of solidity from the centre where they are hardest, to the circumference where they are softest. The outermost layer, which is the softest of all, is denominated the *Alburnum*, perhaps from its being of a brighter white than any of the other layers, either of wood or bark, from which character, as well as from its softer texture, it is also easily distinguished, though in the case of some plants, as in that of the Poplar and Lime-tree, this peculiarity of character is not very apparent.

Forming externally alburnum,

And internally perfect wood.

From the peculiarity of external character however, which it possesses in general, it was at one time thought to be a substance essentially different from that of the layers which it invests. The ancients, whose phytological opinions were often very whimsical, supposed it to be something analogous to the fat of animals, and intended perhaps to serve as a sort of nutriment to the plant in winter. But it is now known to be merely wood in a less condensed state, being yet lighter and softer than the interior layers, but acquiring strength and solidity with age. It does not however acquire its utmost degree of solidity till after a number of years, as is plain from the regular gradation observable in the solidity of the different layers. But if a tree is barked a year before it is cut down, then the Alburnum is converted into wood, in the course of that year.*

---

* Phys. des Arbres, liv. i. chap. iii.

SUBSECTION II.

Discoverable on a horizontal section.

Divergent Layers.—The divergent layers (*Pl.* VIII. *Fig.* 13.), which intersect the concentric layers in a transverse direction, constitute also a considerable proportion of the wood, as may be seen in a horizontal section of the Fir or Birch, or of almost any woody plant, on the surface of which they present an appearance like that of the radii of a circle. But if the wood is split longitudinally, in a direction passing through the centre of the stem, fragments of the divergent layers will be seen adhering to the surface of the fracture, in the form of large and smooth plates, which cross the concentric layers and form a sort of binding and cement to the whole, exhibiting a slight resemblance to a fine but irregular wicker-work. This appearance is peculiarly conspicuous in the trunk of the Elm-tree and Oak, if riven in the above direction; and in the latter even after having been planed, the irregular fragments of the transverse plates being of a deeper shade of colour than the rest of the wood, as may often be observed even in the flooring or wainscoting of a room, of which the materials are oak.

---

* Du Hamel, Mem. de l'Acad. 1737.

Improperly denominated medullary rays.

The divergent layers were at one time, and with some botanists are still, denominated the Medullary Rays, upon the supposition of their originating in the pith. This opinion was entertained by Du Hamel, and supported by the following fact: Having taken the trunk of a Lime-tree of about four or five inches in diameter, about the middle of which there was a bud, and cut it asunder obliquely in the direction of the bud, and having examined the section with great care, he thought he could trace a ray of a whiter shade than the rest of the wood, extending from the pith to the bud. The conclusion therefore was, that the bud is formed from the pith, and that the ray extending from the one to the other is with propriety denominated a medullary ray.* But if it is only recollected that buds are formed on the surface, and rays in the interior of the trunk, long after the pith has disappeared in the centre, the impropriety of the appellation of the medullary rays will be rendered evident, as well as the necessity of looking out for a different origin both to the bud and ray. The thicker and more conspicuous of the divergent layers may indeed be traced from the circumference to the centre; but the thinner and intermediate layers cannot always be so traced. Daubenton says he could not trace any of them quite to the pith, but that is by no means the case in all species of wood.

---

* Phys. des Arbres, liv. i. chap. iii.

Such then is the general aspect of the ligneous layers whether concentric or divergent, as discoverable in the transverse or horizontal section of the stem or branch. But it is necessary to pursue the investigation still farther, and to endeavour to ascertain the component parts of the layers themselves, till they are at last reduced to their ultimate and elementary organs.

SUBSECTION III.

Concentric layers divisible into layers still smaller.

Structure of the Layers.—If any one of the concentric layers, as they present themselves at first sight on a horizontal section of the stem, is taken and inspected minutely, but particularly with the help of a good glass, it will be found to consist of several smaller and component layers, which are themselves composed of layers smaller still, till at last they are incapable of farther division. In the Alburnum the aggregate mass of layers is very often separable merely with the hand assisted by a fine instrument, but in the matured wood it is separable only by maceration or decay. But the divergent layers do not seem capable of division into finer layers, whether by the knife or maceration. And as you cannot divide them into component layers, so neither can you separate the two sets of layers so as to exhibit each of them entire. But as the divergent layers are soluble in fluids, in which the concentric layers are not, the latter may be exhibited pretty entire by means of the destruction of the former. Du Hamel macerated, for a long time, a piece of the trunk of an Oak-tree in water, in which the divergent layers are soluble, and found that the minuter divisions of the concentric layers consisted ultimately of an assemblage of longitudinal fibres, so as to form a net-work similar to that of the liber. The same thing may be very distinctly seen in the stem of a full grown Cabbage, that has been pulled up out of the soil, and exposed for some considerable length of time to the action of the atmosphere. The divergent layers have been decomposed, and the concentric layers are left insulated. But one of the best and most beautiful of all examples of this kind is that of the net-work exhibited in the layers of the large roots of the Artichoke, which when exposed to the weather till the divergent layers have been decomposed, present a multitude of skeletons of concentric layers, forming a net-work of fibres as fine as a piece of lace.

Which form a fine net-work.

But this mode of analysis gives us no knowledge of the structure of the divergent layers, because they are decomposed in the process. We must consequently have recourse to the aid of the microscope. And if a thin slice of one of them is

Divergent layers composed of parallel threads of vesicles.

taken, we shall suppose from a piece of Oak or Elm, and put under a good glass, it will be found to be composed of an assemblage of parallel fibres or threads of contiguous vesicles, not forming a net-work, but closely crowded together and compressed into a thin layer, being apparently nothing more than the vesicles or cellular tissue of the pulp that originally existed in the Alburnum, now deprived of its parenchyma, but still filling up the interstices of the concentric layers, and binding them together like a cement.

To complete the analysis, Senebier macerated, in water and spirits of wine, a slice or layer taken from the trunk of a Fir-tree, and reduced it to a mere skeleton. It presented a net-work of which some of the areas of the meshes were occupied with an intervening substance, and some empty. But the intervening substance remained only where the slice was thick. Where the slice was thin it had disappeared altogether, having been dissolved in the water or spirits of wine. But it is known that the cellular tissue is soluble in either of these fluids. The conclusion therefore was, that the interstices of the net-work were occupied with cellular tissue, crossing the longitudinal layers in a horizontal direction, and uniting and cementing them together by insinuating itself between them.

But a slice of the transverse section presented also the appearance of a net-work after maceration; which shows that the concentric layers must be united together, by something more than mere cellular tissue.* Such at least was the inference of Senebier. But it is certain that the divergent layers acquire a degree of consistence in their mature state, that can long resist the action of the atmosphere. On the horizontal section of the trunk of an Elm-tree that had been exposed for a great length of time to the weather, and had begun to be in a state of decay, I inspected minutely the net-work in question, and found it to be evidently composed of the remains both of concentric and divergent layers. But the divergent layers are composed of cellular tissue, which, if in its mature state, it can long resist the action of the atmosphere, might for the same reason have long resisted the action of the solvents employed by Senebier; and might still have been the only bond of union between the concentric layers; the substance which first disappears, and renders the network visible, being the indurated parenchyma contained within the cellular tissue, and assuming in the Alburnum a soft and floccy appearance, rather than the cellular tissue itself.

And both sets interwoven like the threads of a web.

The concentric layers therefore are composed of longitudinal fibres, generally forming a net-work; and the divergent layers, of parallel threads or fibres of cellular tissue, extending in a transverse direction, and filling up the interstices of the network; the two sets of fibres being interwoven and interlaced together, so as to form a firm and compact body in the matured layers; and thus corresponding exactly to the description given of them by Grew and Malpighi, in which the longitudinal fibres are compared to the warp, and the transverse fibres to the woof of a web.

---

* Phys. Veg. vol. i. p. 209.

SUBSECTION IV.

Composed of fibres still smaller.

Vegetable Fibre.—In plants that are purely herbaceous, and in the herbaceous parts of woody plants, it has been seen that the stem or other herbaceous part, is furnished with a number of notable and often insulated fibres passing longitudinally throughout its whole extent, as in the stipe of *Aspidium Filix-mas*, or leaf-stalk of the Elder. These fibres, when viewed superficially, appear to be merely individuals, but when inspected minutely and under the microscope, they prove to be groups or bundles of fibres smaller and minuter still, firmly cemented together, and forming in the aggregate a strong and elastic thread; but capable of being split into a number of component fibres, till at last you can divide them no longer.

The longitudinal fibres being the strongest,

The same is the case with the longitudinal fibres composing the net-work of the layers both of the bark and wood, as well as with the fibres of the divergent layers, by which those of the concentric layers are crossed; which last two indeed are not only different in their external structure, as has been already seen, but also in their degree of tenacity even in the same plant. This is obvious from the well known fact of the splitting of the wood which you can always easily effect in the direction of the longitudinal fibres, but never in the direction of the transverse fibres, owing evidently to the strong and tough fabric of the former; and to the slender and delicate contexture of the latter.

Hence also the firmness or hardness of any particular species of wood depends upon the number and compactness of its longitudinal fibres. The longitudinal fibres of *Guaiacum* and Mahogany are numerous and closely united, and the wood very hard; while the longitudinal fibres of the Fir-tree and Poplar are few and scattered, and the wood very soft; the hardest wood being always of slowest growth, as in the case of the Oak and Box; and the softest wood of quickest growth, as in the case of the Horse-chesnut and Ash.

And apparently composed of a succession of rings;

If the fibres of the bark or wood are examined individually with a good glass, they will not be found to present, as might perhaps have been expected, a smooth and uniform surface; but rather an appearance as if composed of a succession of rings, giving them a sort of slight resemblance to the awn of Barley.* In the liber and alburnum they are soft and gelatinous; but in the interior layers of the wood, and exterior layers of the bark, they have acquired their utmost degree of solidity and cohesion, which may be appreciated from the solidity and cohesion of the wood which they form, according to the weight that any given length and diameter will sustain. When viewed under the microscope they are generally transparent, and particularly at their points of inosculation. But in some plants they are much finer than in others; or the bundles they form are smaller, as well as the meshes of the net-work they compose, varying in their aspect and properties in almost every species; and yet exhibiting a peculiarity of character that is always uniform. Hence the carpenter can distinguish the different species of timber by inspecting the surface of the section or fissure, with as much facility as the botanist can distinguish the different species of plants by regarding their external habit.

---

* Seneb. Phys. Veg. vol. i. p. 59.

As well as really differing in delicacy of fabric.

But the quality of the fibres is not invariably the same throughout all the different organs of the plant. In the leaf they are more delicate than in the stem, and in the flower they are more delicate than in the leaf. And yet this is not more than what might have been expected from the analogy of the vegetable to that of the animal in the applicability of its different organs to the functions they are to perform—the nerves or organs of sensation in the animal being much more delicate in their fabric than the muscles by which a limb is extended.

And yet, delicacy or strength of fabric does not constitute the whole of the difference between the fibres of the several organs of the plant. For they are often also different in kind as well as in degree, as may be exemplified in the fibres of the bark and wood. If the fibres of the former are separated by the destruction of a part, the part is again regenerated, and the fibres are again united, without leaving behind them any traces of a wound. But if the fibres of the latter are separated by the destruction of a part, the part is never regenerated, and the fibres are never united.

CHAPTER III.

ELEMENTARY OR VASCULAR ORGANS.

FROM the previous analysis of the composite organs it appears they are all ultimately reducible to fibres, cellular tissue with or without parenchyma, and reticulated membrane—which we must consequently regard as being, under one modification or other, the ultimate and elementary organs of which the whole mass of the plant is composed. If it is asked of what the elementary organs are themselves composed, the reply is—they are composed, as appears from the same analysis, of a fine, colourless, and transparent membrane, in which the eye, aided by the assistance even of the best glasses, can discover no traces whatever of organization; which membrane we must also regard as constituting the ultimate and fundamental fabric of the elementary organs themselves, and by consequence of the whole of the vegetable body.

But though we have thus ascertained the ultimate and elementary organs of the whole of the vegetable body, together with the primary fabric of which they are themselves composed, we have not yet finished our inquiries with respect to them. A question or two remains yet to be instituted and answered, with regard to the structure of the longitudinal fibres. Are they tubular, or are they solid? and if tubular, are they all of the same species?

Longitudinal fibres tubular.

It has been asked, indeed, by some phytologists whether or not plants are furnished with vessels analogous to the blood vessels of the animal system. But if it is admitted that plants contain fluids in motion, which cannot possibly be denied, it will follow as an unavoidable consequence that they are furnished with vessels conducting or containing such fluids. We have already seen that the pulp and pith are composed of clusters of bags or bladders, which are, at least in the young shoot or plant, filled with a vegetable juice. But it is not with regard to them that any doubt has existed; but with regard to the structure of the longitudinal fibres, which some have described as tubular, and others as solid. The latter have said that it is impossible to discover any tubular cavity in such fibres even with the aid of the best glasses; and have contended that it is not likely they should contain such cavity from their capability of indefinite division. But the fact is, that the tubular structure of the longitudinal fibres may be distinctly perceived, as well as legitimately inferred, in the case both of herbaceous and woody plants.

As discoverable in the stem of herbaceous plants.

If the stem of a plant of Marigold is divided by means of a transverse section, the divided extremities of the longitudinal fibres, arranged in a circular row immediately within the bark, will be distinctly perceived, and their tubular structure demonstrated by means of the orifices which they present, particularly when the stem has begun to wither.* The same sort of structure may be observed in the stem of cucurbitaceous plants also, particularly in that of the Gourd, in which there are besides discoverable several sets of longitudinal tubes situated near the centre, and of considerable diameter.

Objections.

But it has been pretended that the above apertures are not the orifices of vessels, because they do not empty themselves when cut. This would not be a very formidable argument if it were even the fact, which it is not; as there are many plants to be met with whose vessels do empty themselves when cut.

Answered.

If you cut or break asunder the stem of any species of Spurge the vessels will immediately begin to empty themselves on both surfaces formed by the section or fracture; and if the vessels do not so empty themselves in all herbaceous plants, they may be emptied, at least in part, by means of pressure.

---

* Ventenat. Tab. du. Reg. Veg. vol. i.

Additional proofs.

But if this were not the case, I think the tubular structure of the longitudinal fibres might be demonstrated even from other facts. Having taken the peduncle of a male flower of *Marchantia polymorpha* and pulled it gently in two, I found that the central and longitudinal fibre had not been fractured at the point, where the rest of the peduncle was fractured, but at the distance of about an inch. The consequence was, that it was drawn out of the surrounding substance as out of a sheath, and laid bare to the above extent. It was perfectly colourless and transparent, and what appeared to the naked eye to be but one fibre, was found under the microscope to be composed of a number of smaller fibres amounting at least to twelve, perhaps twenty, and closely adhering together by the whole of their length. In these I could plainly perceive the existence of a fluid, which was in some ascending and in others descending with a quick but interrupted motion, like that of the mercury in a tube that has not been well cleaned, or of the air in a spirit of wine level. From this I think the tubular structure of the longitudinal fibres, together with their capacity of conducting fluids, is clearly demonstrated; as well as from the visibility of their aperture on the transverse section.

Observations of Leuwenhoeck.

Leuwenhoeck, who was a great advocate for the vascular structure of the vegetable fibre, pursued his investigations even into the interior of the tubes themselves, in which he appears to have made some minute discoveries. He describes the fibres of the vegetable, whether vertical and horizontal, as constituting tubes whose diameter he attempted to measure, and whose interior he found to be lined with a sort of fine down.* It is probable, however, that he was indebted for part of his discoveries to microscopical deception. But it must be confessed that the accuracy of his observations is in some degree corroborated by those of Du Hamel, who having contrived, by means of coloured injection, to render conspicuous the vascular structure of the fibres of several different species of reed, describes them as being enveloped in a medullary substance, and lined on the interior surface with a fine down.† Tournefort describes the same appearances as visible in the longitudinal tubes of the stem of the *Potamogeton* and *Nymphæa;* in which last they are easily detected, owing to the large diameter of the tubes, though I should be inclined to denominate them internal spines rather than a down, they appear so large and strong.

Du Hamel.

Tournefort.

But the tubular structure of the fibres is not so readily distinguished in the stem of woody plants, though the evidence of its existence is sufficiently satisfactory. It cannot be denied that wood is, at least, permeable to water, as is plain from the following facts. A wedge of wood driven into the

As discoverable in woody plants.

---

[*] Arcana Naturæ, p. 12.

[†] Phys. des Arb. liv. i. chap. i.

chink of a rock will expand very perceptibly if wetted with water. The water must consequently have been absorbed. Spirits of wine will evaporate out of a wooden box however well it may be closed; and mercury may be forced even through a piece of hard wood by means of the air pump. Hales made water pass through a branch of an Apple-tree cut in autumn, merely by putting the one end of it in a glass tube which he filled with water. It may be said, indeed, that these facts are no proof of the existence of tubular fibres; and that the passage of the fluid is to be accounted for upon the principle of filtration. It is to be recollected, however, that the principle of filtration will not account for the ascent of the sap to the summit of the vegetating plant, particularly with the force by which it is known to ascend.

Analogy also authorizes us in supposing that woody plants are furnished with tubular fibres as well as herbaceous plants, since they are equally necessary to the conveyance of the fluids passing through them. And though the tubular fibres of woody plants do not, like those of many herbaceous plants, readily part with their juice by means of cutting or pressure, yet they will readily part with it if exposed to the action of a strong heat.

But the tubular structure of the longitudinal fibres of woody plants is cognizable also by the eye. On the horizontal section of a piece of wood that has been long exposed to the action of the atmosphere so as to exhibit symptoms of incipient putrefaction, the orifices of the tubes may be distinctly perceived. They are particularly apparent on the horizontal section of decayed trunks of the Elm-tree, in which they are arranged in circular rows in the direction of the concentric layers. In this case, however, they exhibit merely a skeleton; but Hedwig observed them in the transverse section of a branch of the Pear-tree detached even in the spring, while the sap was yet flowing. They were largest and most distinct in the layers immediately under the bark, but diminishing in their diameter towards the centre.*

Objections.

It has been maintained, however, that the cavities observable in the horizontal section of the wood are not the orifices of tubular fibres, but of spaces formed by the circular disposition of sets of fibres closely united together, but leaving a tubular opening in the centre. But if this were even the fact, still these openings are as completely a vessel as if the fibres themselves were tubular; and it is but of little consequence in the mean time to know how the tubes are formed, if they are but acknowledged to exist. Regarding it therefore as certain that plants are furnished with longitudinal tubes, as well as with cells or utricles for the purpose of conveying or containing their alimentary juices, I shall proceed to the specific illustration of both together with their peculiarities and appendages.

Answered.

---

* De Fibræ Vegetabilis Ortu, § i.

SECTION I.

Utricles.

Description.

The Utricles are the fine and membranous vessels constituting the cellular tissue of the pith and pulp already described, whether of the plant, flower, or fruit. Individually they resemble oblong bladders inflated in the middle, as in the case of some plants; or circular, or hexagonal cells, as in the case of others. Collectively they have been compared to an assemblage of threads of contiguous bladders or vesicles, or to the bubbles that are found on the surface of liquor in a state of fermentation.

As existing in herbs.

But this description is applicable to them only as they occur in herbaceous plants, or in the soft and tender parts of woody plants; though in either case they are not always of the same figure in all the different parts of the same plant. In the leaf-stalk of the Artichoke, for example, their diversity of figure is very conspicuous, presenting, in their free and uncompressed state, whether on a horizontal or longitudinal slice, a beautiful assemblage of hexagonal cells; but in their crowded and condensed state, as they approximate the longitudinal fibres, an assemblage of tubular threads successively inflated and contracted. In woody plants their diversity of figure is still greater, as must appear evident if it is but recollected that they constitute not only the bags or bladders of the cellular integument and pith, and of the pulp of the leaf and fruit, but also the very fabric of the divergent layers themselves, assuming a peculiarity of aspect according to the degree of compression they sustain from other parts; or according to the degree of induration they may have undergone, ascending progressively from the succulent texture of the pulp and pith to that of the firm and perfect wood.

In trees.

The structure of the utricles of the tree is also said to be different from that of the utricles of the herb, the former being composed of a single membrane, and the latter of a double membrane. Senebier is, however, of opinion that they consist of a double membrane in both cases, though not so conspicuous in the one case as in the other, owing to the more compact and condensed texture of the wood. But of this I can say nothing from any observations of my own, having never been able to satisfy myself of the existence of the double membrane in either case.

United to the longitudinal tubes.

However, they are all mutually connected with one another and also with the other vessels of the plant; which double union is rendered evident by means of coloured injections, or rather by means of the absorption of coloured infusions, from which the utricles, as well as the longitudinal tubes, always receive a tinge. But in the petals, stamens, and pistils, they do not seem to be connected with the longitudinal vessels as in the other parts of the plant; and perhaps they are also somewhat peculiar in their organization as may be inferred from the following fact—namely, that the white and milky juice, with which they are filled in the stem and branch of the Fig, does not ascend above the peduncle. In the pith they are generally larger than in any of the other parts of the plant; and in plants from which part of the trunk has been cut off, it has been remarked that they become altogether larger and more inflated than in plants of the same species that have not been so treated; which enlargement is perhaps to be accounted for from the superabundance of sap that now pervades them in consequence of the diminished bulk of the vegetable. Senebier speaks of other utricles distinct from those of the parenchyma, by which he means the pulp or pith, but without saying any thing explicit on the subject, and without representing them as different in form.*

SECTION II.

Tubes.

Their different sorts.

The Tubes are the vessels formed by the cavities of the longitudinal fibres, whether as occurring in the stem of herbaceous plants, or in the foot-stalk of the leaf and flower, or in the composition of the cortical and ligneous layers, or by longitudinal openings pervading the pulp itself, as in the case of the

---

* Phys. Veget. vol. i. p. 100.

Vine. They have generally been characterized under the denominations of proper vessels, lymphatics, and tracheæ. But as this is rather premature reference to their different uses, which is besides not altogether correct, I shall adopt with a little alteration the denominations introduced by M. Mirbel, as arising from their form or structure. The first and primary division founded upon this principle is that by which they are distributed into large tubes, and small tubes.*

SUBSECTION I.

Large Tubes.—The Large Tubes are tubes distinguishable by the superior width of the diameter which they present on the horizontal section of the several parts of the plant.

Their several species.

In herbaceous plants they are represented by M. Mirbel as being always found in the centre of the longitudinal fibres; while in woody plants they are often dispersed at random; though they sometimes form regular groups, which are sometimes concentric circles constituting the principal mass of the ligneous layers. They are generally to be found in great abundance surrounding the medullary canal. They are found also in the bark, and are capable of being traced from their origin in the extreme fibres of the root, to their termination in the extreme summit of the plant, uniting in the body of the root, traversing the collar, penetrating and ascending the stem in a parallel direction, separating and entering the branches, buds, and foot-stalks; separating again and distributing themselves in smaller bundles so as to form the nerves and veins of the leaves and petals, the slender fibres of the stamens and pistils, and the firm and woody fibres of the fruit. In the *Lichens*, *Fuci*, and *Fungi*, no large tubes are discoverable even with the aid of the microscope; though in the transverse section of most other plants they are visible without a microscope. Such is the substance of M. Mirbel's description of the large tubes which he divides into the five following varieties: simple tubes, porous tubes, spiral tubes, false spiral tubes, and mixed tubes.

---

* Phys. Veget. vol. i. p. 61.

The largest of large tubes.

ARTICLE 1. *Simple Tubes.*—The simple tubes (*Pl.* VIII. *Fig.* 16.), which are the largest of all the large tubes, are formed of a thin and entire membrane, without any perceptible disruption of continuity, and are found chiefly in the bark; though not confined to it, as they are to be met with also both in the Alburnum and matured wood, as well as in the fibres of herbaceous plants. But they are particularly conspicuous in the stem and other parts of the different species of *Euphorbia* and *Periploca;* and in all plants in general containing thick and resinous juices, known by the name of the proper juices, to the ready passage of which their great width of diameter is well adapted. Sometimes they are distinguishable by their colour, which is that of the juices contained in them; being white, as in *Euphorbia;* or yellow, as in Celandine; or scarlet, as in *Piscidia erythrina.* In the plant they are united in bundles, but are detachable from one another by means of being steeped for a few days in spirit of turpentine, when they become altogether colourless and transparent, because the resinous matter which they contained has been dissolved. Senebier says they retain their cylindrical form even in their detached state; and if so, the membrane of which they are composed must be very strong.*

Description.

ARTICLE 2. *Porous Tubes.*—The porous tubes resemble the simple tubes in their general aspect; but differ from them in being pierced with small holes or pores, which are often distributed in regular and parallel rows. They are found in most abundance in woody plants, and particularly in wood that is firm and compact, like that of the Oak; but they do not, like the simple tubes, seem destined to contain any oily or resinous juice.

Description.

ARTICLE 3. *Spiral Tubes.*—The spiral tubes (*Pl.* VIII. *Fig.* 17.) are fine, transparent, and thread-like substances, occasionally interspersed with the other tubes of the plant, but distinguished from them by being twisted from right to left, or from left to right, in the form of a cork-screw. They occur in most abundance in herbaceous plants, particularly in acquatics; but they are also to be met with in woody plants, whether shrubs or trees. If the stalk of a plant of the liliaceous tribe, or a tender shoot of the Elder, is taken and partly cut across, and then gently broken or twisted asunder, the spiral tubes may be seen even with the naked eye, uncoiled somewhat, but remaining still entire even after all the other parts have given way; and if the inferior portion of the stalk is not very large, it may be kept suspended for some considerable time merely by the strength of the tubes; which, though now almost entirely uncoiled by means of the weight they support, will, when they finally break, suddenly wind up at each extremity, and again resume their spiral form.

---

* Phys. Veg. vol. i. p. 92.

As occurring in liliaceous plants.

First detected by Grew and Malpighi,

And named tracheæ.

Grew and Malpighi, who first discovered and described them, represented them as resembling in their appearance the Trachea, or windpipe of animals, and designated them by the same term; an appellation by which they are still very generally known. Du Hamel endeavoured to convey an idea of their form by comparing it to that of a piece of riband rolled round a small cylinder, and then gently pulled off in the direction of its longitudinal axis. The figure of the riband becomes, thus, loosely spiral. This is a very good illustration of the figure of the spiral tubes in their uncoiled state; but it does not represent them very correctly as they exist in the plant. But the best illustration of this kind is perhaps that of Dr.

Thomson's. Take a small cylinder of wood, and wrap round it a piece of fine and slender wire, so as that the successive rings may touch one another, and then pull out the cylinder. The wire as it now stands will represent the spiral tubes as they exist in the plant. And if it is stretched by pulling out the two extremities, it will represent them in their uncoiled state also.*

But although the spiral tubes are to be met with in almost all plants, they are not yet to be met with in all the different organs of the plant; or at least there are organs in which they occur but rarely, or in very small numbers.

Not easily detected in the root,

They do not seem to occur often in the root, or at least they are not easily detected in it. Grew and Malpighi do indeed represent them as occuring often in the root, the former referring for examples † to the roots of plants in general, and the latter ‡ to those of the Asparagus, Poplar, Convolvulus, Elm-tree and Reed; all of which I have examined with great care, without being able to discover any spiral tubes. Senebier says he found them in the root of the Balsams and Thorn-apple; § in examining which I was equally unsuccessful as in examining the former. I cannot, however, doubt the accuracy of the observations of the above phytologists, and can only set down my own want of success in discovery to the score of some defect, either in the specimens examined, or in my mode of examination. Indeed the only root in which I have ever found them, after examining a very considerable number, is that of the common garden Lettuce, known by the name of Cos Lettuce. Having taken the root of a plant that was just putting out its flowers, and stripped it of its bark, I then cut it partly across about the middle of its length, and broke the remainder of it gently asunder. On examining the surface of the fracture with the microscope, fragments of spiral tubes were seen projecting from it near the centre. They did not seem very tenacious of their spiral form; and when once uncoiled did not readily resume it.

---

* Thomson's Chemistry, vol. iv. p. 405.

† Anatomy of Roots, chap. iv.

‡ De Radice Plantarum. Opera Omnia.

§ Senebier, Phys. Veg. vol. i. p. 109.

Or stem of woody plants;

The spiral threads are to be found also in the stem and branch; but not in all parts of them; or at least not in all periods of their growth. It seems very doubtful whether they exist at all in the bark. Daubenton professes indeed to have seen them in it; but I believe no one else ever has; so that we are perhaps sufficiently well warranted in entertaining our doubts. It seems also very doubtful whether they exist in that part of the stem which consists of matured wood, though Daubenton professes to have seen them in the wood of the *Cedrela;* in which case he does not altogether stand alone; as they are represented both by Grew and Hedwig, as visible also in the wood. But I believe they have not been found in the matured wood, by any other vegetable anatomists. Du Hamel never met with them in any of the woody parts of woody plants, except in the young and herbaceous branches.* Mirbel expresses himself to the same effect.† And Mr. Knight, who has examined the subject perhaps still more recently, could not detect them in any of the permanent parts of such plants, except in the annual shoot.‡ My own observations on this subject have had nearly a similar result. Among many subjects of examination I shall mention only the Elder, Willow, Hawthorn, Cherry, and Elm-tree. In the three former I found them only in the annual shoot, situated immediately without the pith, or rather imbedded in the Alburnum; though in the Elder some of them seemed to be imbedded even in the pith itself. In the Cherry I found also a few, very few similarly situated in the branch of two years old; but none in wood older than that. And in the Elm-tree I have sometimes thought I had discovered them even in the matured wood. Having placed under the microscope a very thin slice taken from a piece of the trunk of an Elm-tree, that had been felled at least six or seven years, I thought I was able to trace the remains of the spiral tubes. The slice was taken from the surface of a longitudinal section passing through the centre of the trunk, and clear of divergent layers; and the tubes seemed to appear most distinct when the slice was so placed as to present their longitudinal dimensions to the light. They seemed to resemble ribands wrapped spirally round a cylinder rather than to form separate vessels, which corresponds very well to their appearance even in the succulent parts of many plants, as described by Knight. Some of them seemed even separate and entire. And yet upon repeated observation I have not been able to satisfy myself entirely on this point, though I have ventured to state the case circumstantially, as being the probable means of inducing some one to take up the subject who may be more felicitous in his investigations. It cannot be said to be a vain or fruitless inquiry. For as they are known to have existed at least in the tender shoot, it will follow that they must exist in one shape or other in the matured wood also. And if their spiral form is there obliterated, under what other aspect do they now appear? It seems certain from the observations of Hedwig, that they assume a different figure in different stages of the plant's growth. In the peduncle of the *Colchicum autumnale*, the rings of the tubes are closer when it begins to appear above ground, than at the time of flowering; from which he concludes that they are at length entirely obliterated, and the tubes converted into woody fibre. But sometimes it is difficult to detect them even in the young shoot; though they are generally to be observed by breaking it gently asunder, and then examining the surface of the fracture with a microscope. In this case they appear in small fragments projecting from the surface, and somewhat uncoiled; but if the shoot is split longitudinally, a portion of them will sometimes be found extended longitudinally on the surface of the fissure in an uncoiled state.

---

* Phys. des Arb. † Phys. Veg. vol. i. p. 67. ‡ Phil. Trans.

But easily detected in the stem and branches of herbaceous plants;

In the stem and branches of herbaceous plants they are generally discoverable without much difficulty, accompanying the longitudinal fibres and forming part of the bundles. I have found them in the stem and branches of the Burdock even in winter, when the fragments of the mature plant had become quite indurated by means of their exposure to the weather.

As also in the leaf-stalk,

They are also very easily detected in the footstalk both of the leaf and flower, accompanying, or rather seeming almost entirely to compose, the bundles of longitudinal fibres. This may be well exemplified in the leaf-stalk of the Artichoke when young and fresh, in the fibres of which they are not only remarkably large and distinct, but also remarkably beautiful; some of them exhibiting in their natural position the appearance of spiral coats investing interior fibres rather than that of forming a distinct tube, and seeming when uncoiled to be themselves formed of a sort of net-like membrane, consisting of three principal and longitudinal fibres.

And leaf, They are discoverable also in the leaf, though not quite so easily detected as in the leaf-stalk. But if a leaf is taken and gently torn asunder in a transverse direction, fragments of the spiral tubes will be seen projecting from the torn edges, and generally accompanying the nerves.

But rarely in the calyx and corolla, They are also to be found both in the calyx and corolla, but not so generally as in the leaf, on which account some botanists have decided rather too hastily with regard to their non-existence in these parts of the flower. Mirbel says no tracheæ are to be found in the calyx nor in the corolla, except in the claw.[*] But I have found them most unequivocally in the calyx of *Scabiosa arvensis;* and also in the expansion of the corolla of the same plant, as also in the calyx, both common and proper, of *Dipsacus sylvestris;* and in the corolla of the Honey-suckle, in which they appeared to be placed within the nerves, or at least to be closely united to them.

And other parts of the flower, In the other parts they do not seem to occur frequently, or at least it is difficult to detect them. Malpighi represents them indeed as occurring in the stamens,[†] but I have not been fortunate enough to meet with them in the stamens of any flower I have hitherto examined. I have looked for them also in the style of many flowers, and found them in that of the Honey-suckle only.

---

[*] Trait. d'Anat. et de Phys. Veg. vol. ii. p. 19.

[†] Staminum corpus et appensa capsula ligneis fistulis et *tracheis* integrantur. *Anat. Plant*, p. 49.

And seed.

According to the observations of Grew and Malpighi, they are to be met with both in fruits and seeds ; though Hedwig says they are not to be seen in the cotyledons, except during the process of germination, and that only by means of their being moistened with some coloured infusion. But Gærtner says they are conspicuous in the thinner cotyledons even before germination takes place; and Reichel is said to have detected them even in the plumelet and radicle.*

They are elastic.

But in whatever part of the plant they are found to exist, they are always endowed with a considerable degree of elasticity, as has been already noticed. For though they are forcibly extended so as wholly to undo the spires, they will again contract and resume their former figure when the extending cause is withdrawn, and if they are even stretched till they break, the fragments will again coil themselves up as before.

And capable of being uncoiled.

It has been said however, that those of the *Butomus umbellatus*, if once uncoiled, will contract again no more.† But this is true only when they are stretched to a greath length. For when they are stretched gently and moderately they will again contract, as I have proved by experiment.

Malpighi, in the course of some observations on the spiral tubes during the winter season, fancied he had perceived a sort of vermicular and spontaneous movement in them. But as I believe, he thought he saw this movement only once, and as it has never since been seen by any subsequent observer, it appears that we must be content to set it down to the score of microscopical deception, or to the effect of the atmosphere upon the tubes when exposed to its action.

---

* Senebier Phys. Veg. i. 110.

† Mirbel Anat. Veg. i. 68.

Not capable of being uncoiled.

Article 4. *False Spiral Tubes.*—The false spiral tubes are tubes apparently spiral on a slight inspection, but which, upon minute examination are found to derive their appearance merely from their being cut transversely by parallel fissures. They cannot consequently be uncoiled like the true spiral tubes; nor can they be separated into distinct rings; because the continuity of the membrane of which they are formed, and by consequence the extremities of the fissure which may always be discovered by a little attention, prevent that separation. They are somewhat analogous to the porous tubes; for the fissures, like the pores, are furnished with a ring surrounding the lip. But they are more generally found in the soft parts of woody plants than the porous tubes, and often also in herbaceous plants. In the *Lycopodia* and Ferns, they are found in great abundance; and also in the soft parts of the vine.* I have often observed them in vine shoots of about a year old; but not far from the pith; which makes me suppose that they are perhaps formed of the true spiral tubes, by means of a partial union of the spires.

---

* Mirbel, Phys. Veg. vol. i. p. 65.

Description.

ARTICLE 5. *Mixed Tubes.*—The mixed tubes are tubes combining in one individual two or more of the foregoing varieties. Mirbel exemplifies them in the case of the *Butomus umbellatus* or Flowering Rush, in which the porous tubes, spiral tubes, and false spiral tubes, are often to be met with united in one. He seems however to be of opinion that the appearance is to be regarded as being merely an indication of the incipient stage of the process, of the union of the contiguous rings of the spiral tubes, by which they are to be converted into a new form.

SUBSECTION II.

Formed of elongated cells.

Small Tubes.—The small tubes are tubes composed of a succession of elongated cells united like those of the cellular tissue. Individually they may be compared to the stem of the grasses, which is formed of several internodia separated by transverse diaphragms; and collectively to a united assemblage of parallel and collateral reeds. The membrane of which they are formed is often pierced with a great number of pores; but is at the same time thick and strong, being cut with difficulty in a transverse direction, though in a longitudinal direction it is divisible without effort. M. Mirbel says the solidity of the vegetable depends upon the number of interrupted or cellular tubes. They are not discoverable in the embryo, nor even in the young plant at a very early period, but only when the parts have been fully developed, in which stage they are discoverable in most plants without much difficulty, pervading the ramifications of the branched *Lichens*, and the stem of the Mosses; surrounding the fibrous tubes of herbaceous plants, and constituting also longitudinal fibre; and intermingling themselves even with the fibrous tubes of woody plants, and constituting part of the ligneous layers, as well as the prominent ridges with which the surface of vegetables is marked. In the finer and more delicate parts of the plant they are also equally prevalent, accompanying the nerves of the leaves and petals, and forming part even of the stamens and pistils. But in these fine and delicate organs they assume a different aspect, and acquire a degree of consistence resembling that of the cellular tissue. They are generally found to contain a juice, which is sometimes clear and limpid, and sometimes thick and coloured, communicating its colour to the tubes. In the Vine this juice is watery; but in the Fir-tree it is resinous.

Containing a juice.

SECTION III.

Apertures.

Species.

It has been seen in the foregoing analysis of the elementary or other organs, that the continuity of the membrane composing them is often interrupted by the occurrence of a number of apertures or openings effected in its fabric, and affecting its general aspect; and which may be reduced to the two following species: namely, Pores and Gaps.

SUBSECTION I.

Description.

Pores.—Pores are small and minute openings of various shapes and dimensions, that seem to be destined to the absorption, transmission, or exhalation of fluids. They are distinguishable into the two following sorts: Perceptible Pores, and Imperceptible Pores.

Found in the epidermis by Hedwig,

ARTICLE 1. *Perceptible Pores.*—The perceptible pores are either external or internal, and are the apertures described by Hedwig as discoverable in the net-work constituting the epidermis; or by Mirbel as perforating the membranes composing the cells and tubes, and forming a communication between them. Saussure, in his observations on the leaves and flowers of plants, says indeed that he could discover no pores in the epidermis. And yet it is plain that he describes under the appellation of glands what Hedwig describes under the appellation of pores, though they might not use the term epidermis in the same extent. But Senebier, who understood by the term the same as Hedwig, says he looked for the pores in question in a great variety of plants, and with the assistance of the best microscopes, but all in vain, not having been able to detect them in any one instance.*

This might be thought to throw a degree of doubt upon the accuracy of Hedwig's observations. But M. Decandolle, who has also investigated the subject with great care, establishes the fact of the existence of the pores in question, in the most satisfactory manner, and introduces much of new and additional remark; regarding them as being connected with the ultimate ramifications of the leaf-stalk, as dispersed throughout the parenchyma, and grounding his opinion upon the appearances exhibited in the leaves of *Crassula punctata, lactea,* and *Cotyledon.* He believes them to be organs of insensible perspiration, and observes that they are never to be met with on the nerves of the leaf, where external hairs, on the contrary, are always situated. He adds, that no pores are to be found upon the stalks of any plants, except such as are of a soft texture approaching to that of leaves; nor upon fleshy fruits, such as Pears, Peaches, Gooseberries; nor upon roots; nor upon the bulbs of liliaceous plants; nor upon plants really acotyledonous; nor upon plants that are wholly submersed.† The general accuracy of the above statement is farther confirmed by the observations of M. Mirbel, who regards the pores in question, as being organs both of transpiration and absorption.*

---

* Phys. Veg. vol. i. p. 456.

† Journ. de Phys. tom. iii. p. 130.

The doctrine of external and perceptible pores therefore, as existing in the epidermis, may be regarded as perfectly established. And with the help of a good microscope they are not very difficult of detection, at least in the leaves of herbaceous plants. I have observed them distinctly in the leaves of the following species: *Saponaria officinalis, Sagittaria sagittifolia, Nymphæa lutea, Glaucium luteum, Cynoglossum officinale, Rumex acetosa,* and *Tamus communis;* as also in the leaves of the several species or varieties of *Brassica* and *Lactuca,* cultivated in the gardens, and of the Oak, Poplar, and Lilac.

In most of the above examples they are discoverable on both surfaces of the leaf, exhibiting the oval aperture more or less dilated, as described by Hedwig, together with the communicating ducts. But on the upper surface they are fewer and smaller than on the under surface; and in the leaves of trees they are fewer and smaller on both surfaces than in the leaves of herbs; and in no case have I found them so closely crowded together as represented by Hedwig. The areas are generally oval; but in *Nymphæa lutea* they are round, and not easily detected. For in the leaves of this plant the epidermis is so extremely difficult of detachment, that I obtained it only where it had been left by insects that had eaten up the interior pulp. Finally, in the leaves of Lettuce, and in them only, I found the areas and pores, contrary to the representations of Decandolle, situated even upon the nerves; a fact that destroys the universality of the remark by which they are excluded from that situation, and may be regarded as affording an additional example of the truth of the maxim, that says there is no rule without its exception.

---

* Traité de Phys. Veg. vol. i. p. 81.

The internal and perceptible pores or apertures, forming the medium of communication between the different cells and tubes, seem to have been the discovery of M. Mirbel; as I do not recollect to have seen any account of them previous to that which is given in his vegetable anatomy. They are found in the porous tubes, as has been already noticed as well as in the dissepiments of the cells, sometimes extremely minute, and at other times of considerable diameter, but always bounded by a sort of circular lip or ring. In some plants they are but few and scattered; and in others they are numerous and arranged in regular rows, which extend always in a transverse but never in a longitudinal direction, being meant perhaps merely for the lateral transmission of the sap.

And in the porous tubes, and cells.

Article 2. *Imperceptible Pores.*—The imperceptible pores are pores that are not distinguishable by the eye, assisted even with the best glasses; but which are known to exist by the evidence of experiment. In the fine pellicle of pulpy fruits, though displaying evidently the most unequivocal traces of organization, no pores have as yet been discovered. But we must not on that account conclude that it is altogether without pores; or rather, we must conclude that it is still furnished with imperceptible pores. Because it is very well known, that the fruits in question do both absorb and transpire moisture. But if so, there must of necessity exist apertures for the passage of the moisture absorbed or transpired, and by consequence imperceptible pores.

Their existence inferred from the absorption of moisture.

But the diameter of such pores must be extremely minute; as is obvious from the circumstance of their being altogether invisible even after the application of the highest magnifying powers. Their extreme minuteness has been also thought to be farther illustrated from the following fact. If an Apple or other pulpy fruit is placed under the receiver of an air pump, and the receiver exhausted, the air contained in the Apple escapes only by the bursting of the epidermis. Hence it has been thought that the pores are so very minute as to be impermeable even to air.* But this conclusion is perhaps rather too hasty. The epidermis of the Apple may be permeable to air, though not in a state of sudden expansion.

---

* Mirbel, Phys. Veg. vol. i. p. 80.

SUBSECTION II.

Gaps.—Gaps, according to M. Mirbel, are empty, but often regular and symmetrical spaces formed in the interior of the plant by means of a partial disruption of the membrane constituting the tubes or utricles. They seem to be occasioned by the superabundance of the nutritive juices which the vessels are sometimes found to contain without being able to elaborate, and by which they are ultimately ruptured. They do not occur often, except in plants of a soft and loose texture, such as aquatics; though they are sometimes to be met with even in woody plants also.

Perhaps occasioned by superabundance of sap.

In their general aspect they resemble longitudinal tubes interspersed throughout the cellular tissue or pulp, as may be seen in the different species of Potamogeton, or in the rachis of Ferns. But in the *Equisetum* they assume a regularity of disposition that seems to indicate something more than merely the accidental rupture of the vessels.—One gap larger than the rest occupies the centre of the stem, around which a number of smaller gaps are placed in a circular row, which is again encircled with a second row of gaps larger than the last, and alternating with them, and forming in their aggregate assemblage a sort of symmetrical group. In the leaves of herbaceous plants the gaps are often interrupted by transverse diaphragms formed of a portion

Yet sometimes symmetrically arranged.

of the cellular tissue which still remains entire, as may be seen in the transparent structure of the leaves of *Typha* and many other plants. Transverse gaps are said to be observable also in the bark of some plants, though very rarely.*

SECTION IV.

Appendages.

Division.

As the decomposite and composite organs are found to be furnished with several appendages, so also are the elementary organs; for such, at least, I shall at present denominate the internal glands and pubescence.

SUBSECTION I.

As described by Mirbel.

Internal Glands—In the description of the external structure of the plant, we found that certain substances which appear on the surface of the leaves, foot-stalks, and branches, have been regarded as glands, and distributed into different species according to their form or situation. Whether they really perform the functions of glands or not, is a question which is, perhaps, not yet satisfactorily solved. But there are other substances situated in the interior of the plant, and attached to, or incorporated with, the elementary organs, which have been also regarded under the character of glands, particularly by M. Mirbel in his Vegetable Anatomy, and which, if we adopt his opinion, we must consequently denominate internal glands. Such are the small and oblong or circular bodies which Saussure describes as adhering to what he calls the cortical net-work of the epidermis. And although they have been regarded and described by Hedwig as being merely pores, in which light they seem to have been regarded by Grew also; yet no one will venture to affirm that there may not be something glandular in their structure, that is, in the lip or margin by which they are bounded according to the opinion of Mirbel, who regards the circular lips or rings, bounding the pores that perforate the cells or tubes, as being glandular bodies contributing to the elaboration of the juices of the plant, in their passage from one cell or vessel to another.

---

* Mirbel Phys. Veget. vol. i. p. 75.

Thought by Hedwig to be merely pores.

SUBSECTION II.

Internal Pubescence.—Plants are furnished not only with appendages which are fitly included under the appellation of external pubescence; but the elementary and vascular organs of some of them are furnished also with analogous appendages which I shall accordingly denominate their internal pubescence. The internal pubescence seems to have been first noticed by Leuwenhoeck in his microscopical observations on the minute vessels of vege-

First noticed by Leuwenhoeck and Tournefort, tables, and afterwards by Tournefort whose description of it is more explicit, whose observations it is more easy to repeat, and in the repeating of which the pubescence in question is easily detected. The result of my own observations is as follows:

And easily detected in the leaf-stalk of nymphæa.

If a thin slice of the transverse section of the leaf-stalk, or flower-stalk, of *Nymphea lutea* is examined with the naked eye, it will be found to resemble a piece of fine flowered lace, the interstices being in some parts filled up with an intervening substance, or narrowed so as to be scarcely perceptible. The interstices are merely sections of longitudinal tubes or openings pervading the pulp of the leaf-stalk; and the intervening substances with which some of them are occupied are bundles of longitudinal fibres, closely crowded together agreeable to the general structure of herbaceous plants. If the slice is now placed under the microscope, the interstices will appear to be hexagonal, and a great proportion of them, particularly those that are central, will be seen to send out from their internal surface a number of small and pointed or conical substances projecting about half way across the interstice, and appearing under the microscope like little thorns or spines. They are transparent like the external hairs or down, and seem also to be prolongations of the Cellular tissue.

If an additional slice is now taken, the same appearance is again exhibited, and so on in succession throughout the whole of the leaf-stalk, which shows that they must be pretty closely inserted on the internal surface of the tubes or apertures, on a thin and longitudinal slice of which they may also be seen even in their consecutive order.

BOOK III.

OF THE PRIMARY PRINCIPLES OF VEGETABLES.

Their investigation indispensable.

If the principle of a laudable curiosity and grand natural stimulus to the acquisition of human knowledge should fail to induce the phytologist to undertake the study of the primary and constituent elements of which the plant is ultimately composed, the necessity of the case will compel him. For as plants are not merely organized beings, but beings endowed with a species of life, absorbing nourishment from the soil in which they grow, and assimilating it to their own substance by means of the functions and operations of their different organs, it is plain that no great progress can be made in the explication of the phenomena of vegetable life, and no distinct conception formed, of the *rationale* of vegetation, without some specific knowledge of the principles in question, and of their mutual action upon one another. The latter requisite presupposes a competent acquaintance with the elements of chemistry; and the former points out the necessity of a strict and scrupulous analysis of the several compound ingredients constituting the fabric of the plant, or contained within it. The method therefore of analysing such compound ingredients with a view to the ascertaining of their ultimate principles, and of extracting them from the plant where they do not spontaneously present themselves, together with a brief account of their principal properties, as also of their several uses, shall constitute the subject of the two following divisions; not however with a view to teach the very difficult art of vegetable analysis, which is the province of the practical chemist, but rather to exhibit such a sketch of that analysis and its results as may serve to give to the phytological novice a glimpse of what he is yet to study more profoundly; and may be acceptable and useful even to the botanical student who has no desire to become a practical analysist.

PART I.

METHODS OF VEGETABLE ANALYSIS.

Origin of vegetable analysis.

THE necessity by which mankind depends upon the productions of the vegetable kingdom for the support and comfort of life was evidently the original cause of all vegetable analysis. But the methods of the first experimenters were often injudicious from want of scientific views, and the analysis imperfect from want of proper instruments. And hence the results of their investigations were often also contradictory, and the conclusions deduced from them erroneous or absurd. But this is not by any means to be wondered at, when it is recollected that the complicated nature of vegetable substances, in many of their combinations, baffles even now the power of analysis, and can in no case be formed by the synthesis of art.

Object.

If the object of the experimenter is merely that of extracting such compound ingredients as may be known to exist in the plant, the necessary apparatus is simple, and the process easy. But if it is that of ascertaining the primary and radical principles of which the compound ingredients are themselves composed, the apparatus is then complicated, and the process extremely difficult, requiring much time and labour, and much previous practice in analytical research. But whatever may be the object of analysis, or particular view of the experimenter, the processes which he employs are either mechanical or chemical.

CHAPTER I.

MECHANICAL PROCESSES.

Natural. THE Mechanical Processes are such as are effected by the agency of mechanical powers, and are often indeed the operation of natural causes. For it sometimes happens that of the ingredients contained in a plant, part becomes insulated, extricating itself from the organ in which it was formed and elaborated, and detaching itself of its own accord. This may be exemplified in the case of such fluids, existing in excess, as do occasionally burst asunder the vessels containing them, and force their way to the exterior of the plant, where, being now exposed to the influence and action of the air, they are gradually condensed into a solid mass. And hence the origin of gums and other spontaneous exudations.

But the substances thus obtained do not always flow sufficiently fast to satisfy the wants or necessities of man. And men have consequently contrived to accelerate the operations of nature by means of artificial aid in the application of the wimble or ax, widening the passages which the extravasated fluid has forced, or opening up a new one. The plant bleeds now more freely, and the substance wanted is obtained in abundance; whether it is the gum of the Cherry-tree, the resin of the Fir, the manna of the Ash, the opium of the Poppy, or the sap of the Birch or Maple.

Artificial.

But it more frequently happens that the process employed is wholly artificial, and altogether effected without the operation of natural causes. When the juices are enclosed in vesicles lodged in parts that are isolated, or may easily be isolated, the vesicles may be opened by means of rasps or graters, and the juices expressed by the hand, or by some other fit instrument. Thus the volatile oil may be obtained that is lodged in the rind of the Lemon or *Cedrela*. When the substance to be extracted lies more deeply concealed in the plant, or in parts which cannot be easily detached from the rest, it may then become necessary to pound or bruise the whole or a great part of the plant, and to subject it thus modified to the action of a press. Thus seeds are sometimes treated to express their essential oils. And if by the action of bruising or pressing heterogeneous ingredients have been mixed together, they may generally be separated with considerable accuracy by means of decantation, when the substances held in suspension have been precipitated. Thus the acid of Lemons, Oranges, Gooseberries, and other fruits, may be obtained in considerable purity, when the mucilage that was mixed with them has subsided. And if this method is not yet sufficient, recourse must then be had to the additional aid of filtration, which is one of the best and simplest means of separating all such light and feculent, or oily and resinous substances as may happen to make part of the mixture.

Such are some of the mechanical processes, whether natural or artificial, which the experimenter employs, or of which he avails himself, in the analysis of vegetables, and by which a variety of their ingredients may be obtained as they exist already formed in the vegetable. But there is also a variety of other ingredients contained in the vegetable subject, which do not exude spontaneously from the vessels containing them, and which no process merely mechanical can reach. And hence the necessity of chemical processes to complete the analysis of the plant.

CHAPTER II.

CHEMICAL PROCESSES.

The chemical processes are such as are effected by the agency of chemical powers, and may be reduced to the following: distillation, combustion, the action of water, the action of acids and alkalies, the action of oils and alcohols, and lastly fermentation. They are much more intricate in their nature than the mechanical processes, as well as more difficult in their application. Their accuracy, which must at all times have depended upon the state of chemical knowledge, could not at an early period have been very great. And accordingly we find that the principal error of the earlier analysists arose chiefly from the defects of their chemical processes; as well as from a mistaken notion, by which they fancied that all the substances they obtained during the analysis had previously existed in the vegetable; while the fact was, that many of them were entirely the production of the process adopted. But the errors into which experimenters were thus unfortunately led began at length to be suspected; because similar substances were obtained from vegetables possessing totally different qualities; which mortifying fact seems to have repressed for a time the ardour of experimental inquiry, till at length new adventurers arose, who, by exhibiting new views of the subject, and introducing new modes of analysis, enlarged the boundaries of science, and converted even the disappointments of former analysists to their advantage. Boulduc, Herman, and Cartheuser, may be mentioned among the first of the new and more accurate experimenters in the field of vegetable analysis, who were succeeded by Beccaria

Originally very defective.

Improved by the introduction of new methods, and Kessel-Meyer, who were afterwards followed by Rouelle and Bucquet, the former of whom in his dissertations, and the latter in his introduction to the study of the substances extracted from vegetables, gave a precision to the process of analysis and a distribution to the facts ascertained, that tended most materially to the elucidation of the subject.

And application of pneumatic chemistry.

Finally, from the application of pneumatic chemistry as introduced by Priestley, extended by the profound investigations and important discoveries of Lavoisier, and further advanced by the researches of Ingenhoutz and Senebier; together with the experiments of Vauquelin, Proust, Pelletier, Chaptal, Deyeux, Saussure, as also of Thomson and Davy, and lastly of Gay Lussac and Thenard; the vegetable analysis has attained to a degree of perfection surpassing all previous calculation, and beyond which it cannot perhaps be carried very far.

PART II.

PRODUCTS OF VEGETABLE ANALYSIS.

Of the products of vegetable analysis as obtained by the foregoing processes, some consist of several heterogeneous substances, and are consequently compound, as being capable of further decomposition; and some consist of one individual substance only, and are consequently simple, as being incapable of further decomposition. Hence the ground of a subordinate division that shall form the subject of the two following chapters; Compound Products and Simple Products.

CHAPTER I.

COMPOUND PRODUCTS.

Principle of their arrangement.

The compound products of analysis are so very numerous in themselves, or so much diversified in their qualities, as to render it necessary to adopt some definite and specific plan of arrangement in order to give method and precision to the subject; and accordingly different writers have adopted different plans. Rouelle founded his arrangement upon the manner of analysis, according as the ingredients were obtained by means of fire, water, oils, or alcohol. But this circumstance is of too little importance to sanction its application. Bucquet founded his arrangement upon the situation of the several ingredients, as obtained from the root, bark, fruit, or seed. But this plan is liable to the same objection with the former, as presenting no comparative view of the properties of the substances arranged. To remedy this defect the medical or dietetical properties of the ingredients obtained were then adopted as the ground of arrangement; which plan, though it has its utility no doubt with respect to its application to science, is not itself sufficiently scientific. A better method is that by which they are arranged according to their chemical properties, as consisting of oils, acids, alkalies, &c.; or according to some essential characteristic, distinguishing them from one another, and consisting either in the colour, taste, or odour; or in the texture of the parts, as constituting fluids or solids. But the best and most philosophical method of all, and that which supposes the greatest degree of advancement in the science, is that by which they are arranged in the order of their formation or developement in the plant itself. This is to follow the order of nature; though it would no doubt require a greater degree of knowledge in vegetable chemistry, than chemists at present possess, to render the method perfect. But where perfection is not to be attained, it is laudable to have even aimed at it. Fourcroy, who has done much to elucidate the vegetable analysis by means of chemical inquiry, points out the successive periods of the formation and developement of several of the different ingredients, which he adopts in part as the basis of his arrangement, and thus exhibits an example worthy of imitation.* But any method of arrangement will suit the purpose of the present work, provided that the properties of the products of analysis are accurately described. The following is founded merely upon the principle of introducing the several products in such an order that no important reference may be absolutely necessary from any article that precedes to any article that follows—Gum, Sugar, Starch, Gluten, Albumen, Fibrina, Extract, Tannin, Colouring Matter, Bitter Principle, Narcotic Principle, Acids, Oils, Wax, Resins, Gum Resins, Balsams, Camphor, Caoutchouc, Cork, Woody Fibre, Sap, Proper Juice, Charcoal, Ashes, Alkalies, Earths, Metallic Oxides.

SECTION I.

Gum.

An exudation.

THERE is an exudation that issues spontaneously from the surface of a variety of plants, in the state of a clear, viscid, and tasteless fluid, that gradually hardens upon being exposed to the action of the atmosphere, and condenses into a solid mass. This exudation is known by the name of Gum. It issues copiously from many fruit-trees, but especially from such as produce stone-fruit, as the Plum and Cherry-tree, in which it exudes chiefly from fissures in the bark, though it sometimes exudes also even from the fruit. From plants, or parts of plants, containing it, but not discharging it by spontaneous exudation, it may be obtained by the process of maceration in water. It has been found by chemists to consist of several varieties known by the names of Gum Arabic, Gum Tragacanth, Cherry-tree Gum, and Mucilage.

---

* Connaiss. Chem. vol. viii. p. 125.

Gum arabic.

Gum Arabic, which is the most plentiful of all the gums, is the produce of the *Mimosa nilotica,* a native of the interior of Africa and of Arabia—whence its name. In its concrete state, in which it generally assumes the shape of irregular globules, it is considerably hard as well as somewhat brittle; and is destitute both of smell and taste. When pure it is colourless and transparent, though sometimes it is tinged with yellow, varying in its specific gravity from 1300 to 1490.*

It is insoluble in alcohol; but is readily soluble in water; and if the solution is exposed to the action of the atmosphere, the water is gradually evaporated, and the gum again left in a solid mass.

---

* Davy's Agric. Chem. Lect. iii.

According to the analysis of Gay Lussac and Thenard, it consists of the following elements, in the following proportions, 100 parts being the integer: Radical elements.

Carbon	42·23
Oxygene	50·84
Hydrogene	6·93
Saline and earthy matter, a small quantity	
Total	100·*

Gum tragacanth. Gum Tragacanth is the produce of the *Astragalus Tragacantha*, a thorny shrub that grows in the islands of the Levant, from the stem and branches of which there exudes spontaneously a gum resembling gum arabic in its essential properties, but differing from it in the shape assumed by the concrete mass, which is generally that of thin and twisted or channelled plates. It is also less transparent than gum arabic, and not so easily dissolved in water.

Cherry-tree gum. Cherry-tree Gum is obtained from the *Prunus avium* and other species of the same genus, and in general from all trees with stone-fruit, from which it exudes spontaneously and in great abundance. It differs from gum arabic and tragacanth in its concreting in larger masses, and being more easily melted.

Mucilage. Mucilage is found chiefly in the roots and leaves of plants, particularly such as are bulbous and succulent—the bulbs of the Hyacinth and leaves of the

---

* Traité de Chimie Elementaire.

Marshmallow. It is found also in Flax-seed, and in many of the *Lichens*, and is to be obtained only by maceration in water, from which it is separated by means of sulphuric acid.

Uses. Gum, in all its varieties, is capable of being used as an article of food, and is highly nutritive though not very palatable. It is also of considerable utility in the arts, particularly in calico-printing, in which the printer employs it to give consistency to his colours, and to prevent them from spreading. The botanist often uses it to fix his specimens upon paper, for which purpose it is very well adapted. It forms likewise an ingredient in ink; and in medicine it forms the basis of many mixtures, in which its influence is sedative and emollient.

SECTION II.

Sugar.

The commodity known by the name of sugar, and so much used as an article of food, is the produce of the *Arundo saccharifera* or Sugar-cane, a native both of the East and West Indies. The process of manufacture is as follows: The canes, or stems of the plant, when ripe, are bruised between the rollers of a mill, and the expressed juice is collected and put into large boilers, in which it is mixed with a small quantity of quick-lime, or strong ley of ashes, to neutralise its acid, and is then made

Process of manufacture.

to boil. The scum which gathers on the top during the process of boiling is carefully cleared away; and when the juice has been boiled down to the consistence of a sirup, it is drawn off and allowed to cool in vessels which are placed above a cistern, and perforated with small holes, through which the impure and liquid part, known by the name of molasses, escapes; while the remaining part is converted into a mass of small and hard granules of a brownish or whitish colour known by the designation of raw sugar, which when imported into Europe is further purified by an additional process, and converted by filtration or crystallization into what is called loaf sugar, or refined sugar, or candied sugar. Molasses. Raw sugar.

Sugar thus obtained has a sweet and luscious taste, but is without smell. When pure its colour is white; and when crystallized it is somewhat transparent. It is not altered by exposure to the atmosphere, but it absorbs a degree of humidity if the air is moist. It is exceedingly soluble in water, and particularly in boiling water, which will dissolve a quantity of sugar that is even more than its own weight. It is soluble also in alcohol and in the acids, which are likewise capable of decomposing it when concentrated. According to Dr. Thomson its specific caloric is 1·086, its specific gravity 1·4045; and its constituent elements are oxygene, carbon, and hydrogene, in the following proportions: Radical elements.

Oxygene	64·7
Carbon	27·5
Hydrogene	7·8
Total	100·*

Plants containing sugar.

But although the Sugar-cane is here specified as the plant from which sugar is obtained, it is by no means the only plant from which it may be obtained. The juice of the *Acer saccharinum,* or American Maple, yields it in such considerable abundance as to make it an object with the North American farmer, to manufacture it for his own use. A hole is bored in the trunk of the vegetating tree early in the spring, for the purpose of extracting the sap; of which a tree of ordinary size, that is, of from two to three feet in diameter will yield from one hundred and fifty to two hundred pints and upwards in a good season. The sap, when thus obtained and neutralized by lime, deposits by evaporation crystals of sugar in the proportion of about a pound of sugar to forty pints of sap.† It is not materially different in its properties from that of the Sugar-cane.

The juice of the Grape, when ripe, yields also a sugar by the evaporation and the action of pot-ashes, which is known by the appellation of the Sugar of Grapes, and has been lately employed in France as a substitute for colonial sugar, though it is not so sweet or agreeable to the taste.

---

* System of Chem. vol. iv.

† Amer. Trans. vol. iii.

The root of *Beta vulgaris,* or common Beet, yields also, by boiling and evaporation, a sugar which is distinguished by a peculiar and slightly bitter taste, owing perhaps to the presence of a bitter extractive matter which has been found to be one of the constituents of the Beet.

Sugar has been extracted from the following vegetables also, or from their productions:—From the sap of the Birch, Sycamore, Bamboo, Maize, Parsnep, Cow-parsnep, American Aloe, Dulse, Walnut-tree, and Cocoa-nut-tree; from the fruit of the common *Arbutus,* and other sweet tasted fruits; from the roots of the Turnip, Carrot, and Parsley; from the flower of the Euxine Rhododendron; and from the nectary of most other flowers.

Uses. The utility of sugar as an aliment is well known; and it is as much relished by many animals, as by man. By bees it is sipped from the flowers of plants under the modification of nectar, and converted into honey; and also seems to be relished by many insects even in its concrete state; as it is also by many birds. By man it is now regarded as being altogether an indispensable, and though used chiefly to give a relish or seasoning to food, is itself highly nutritive. It is also of much utility in medicine, and celebrated for its anodyne and antiseptic qualities, as well as thought to be peculiarly efficacious in preventing diseases by worms.

SECTION III.

Starch.

Preparation.

If a quantity of wheaten flour is made into a paste with water, and kneaded and washed under the action of a jet till the water runs off colourless, part of it will be found to have been taken up and to be still held in suspension by the water, which will by and by deposit a sediment that may be separated by decantation. This sediment is starch, which may be obtained also immediately from the grain itself by means of a process well known to the manufacturer, who renders it finally fit for the market by washing and edulcorating it with water, and afterwards drying it by a moderate heat.

Properties.

Starch in this state is a fine and white powder without any palpable taste or smell, of which the particles often adhere in considerable masses, but are easily divisible by the touch. If thrown upon water it swims for a time upon the surface, and seems to resist its moistening power, but mixes with it at last, and forms, with cold water, a kind of emulsion, and with boiling water, a thick paste.

When thrown upon red hot iron it burns with a kind of explosion, and leaves scarcely any residuum behind. It has been found by the analysis of Messrs. Gay Lussac and Thenard, to be composed of carbon, oxygene, and hydrogene, in the following proportion:

Composition.

Carbon.	43·55
Oxygene.	49·68
Hydrogene.	6·77
Total	100·

This result is not very widely different from that of the analysis of sugar, into which, it seems, starch may be converted by diminishing the proportion of its carbon, and increasing that of its oxygene and hydrogene. This change is exemplified in the case of the malting of Barley, which contains a great proportion of Starch, and which absorbs during the process a quantity of oxygene, and evolves a quantity of carbonic acid—and accordingly part of it is converted into sugar.

Perhaps it is exemplified also in the case of the freezing of Potatoes, which acquire in consequence a sweet and sugary taste, and are known to contain a great deal of starch, which may be obtained as follows: Let the Potatoes be taken and grated down to a pulp, and the pulp placed upon a fine sieve, and water made to pass through it; the water will be found to have carried off with it an infinite number of particles which it will afterwards deposit in the form of a fine powder separable by decantation, which powder is starch possessing all the essential properties of wheaten-starch.

It may be obtained from the pith of several Sago.

species of Palms growing in the Moluccas and several other East Indian islands, by the following process. The stem, being first cut into pieces of five or six feet in length, is split longitudinally so as to expose the pith, which is now taken out and pounded, and mixed with cold water, which after being well stirred up deposits at length a sediment that is separated by decantation, and is the starch which the pith contained, or the sago of the shops.

Salop.

Cassava.

Sowans.

Salop is also a species of starch that is prepared, in the countries of the East, from the root of the *Orchis Morio, mascula, bifolia,* and *pyramidalis.* So also is Cassava, which is prepared from the root of *Jatropha Manihot,* a native of America, the expressed juice of which is a deadly poison used by the Indians to poison their arrows; but the sediment which it deposits is a starch that is manufactured into bread retaining nothing of the deleterious property of the juice; and so also is Sowans, which is prepared from the husk of Oats as obtained in the process of grinding, and much used among the peasantry of Scotland as an article of food.

List of plants containing it.

The following is a list of plants from the roots of which, according to Parmentier, starch may be extracted.

Arctium Lappa,
Atrŏpa Belladonna,
Polygonum Bistorta,
Bryonia alba,

Colchicum autumale,
Spiræa Filipendula,
Ranunculus bulbosus,
Scrophularia nodosa,
Sambucus Ebulus,
——— *nigra,*
Orchis Morio,
——— *mascula,*
Imperatoria Ostruthium,
Hyoscyamus niger,
Rumex obtusifolius,
——— *acutus,*
——— *aquaticus,*
Arum maculatum,
Iris Pseudacorus,
— *fœtidissima,*
Orobus tuberosus,
Bunium Bulbocastaneum.

It is found also in the following seeds:

Wheat,
Barley,
Oats,
Rice,
Maize,
Millet-seed,
Chesnut,
Horse-chesnut,
Peas,
Beans,
Acorns.

Uses.

Starch, which is an extremely nutritive substance, forms one of the principal ingredients in almost all articles of vegetable food used, whether by man or the inferior animals. The latter feed upon it in the state in which nature presents it: but man prepares and purifies it so as to render it pleasing to his taste, and uses it under the various modifications of bread, pastry, or confectionary. Its utility is also considerable in medicine, and in the arts; in the preparation of anodyne and strengthening medicaments, and in the composition of cements; in the clearing and stiffening of linen; and in the manufacture of hair-powder.

SECTION IV.

Gluten.

How procured.

Gluten is that part of the paste formed from the flour of wheat, that remains unaffected by the water after all the starch contained in it has been washed off. It is a tough and elastic substance, of a dull white colour, without taste, but of a very peculiar smell. It is soluble in the acids and alkalies, but insoluble in water and in alcohol.

Properties.

When exposed to the action of the air it gradually dries and hardens, and assumes a dark brown colour with a slight degree of transparency, resembling glue, except that it is brittle, and breaks like glass. When kept for some time in a place that is moist it undergoes a species of fermentation, in which it swells and emits air bubbles consisting of hydrogene and carbonic acid gas. When exposed in a dry state to heat it cracks, swells, and melts, and exhales a fetid odour, burning like horn or feathers. When distilled it yields ammonia, and an empyreumatic oil, and leaves a charcoal that is with difficulty reduced to ashes.

The above properties of vegetable gluten indicate its relation to animal gluten, particularly the phenomena of its fermentation and destructive distillation, by which it is found to contain, as one of its constituent principles, a portion of nitrogene.

Gluten has been detected, under one modification or other, in a very considerable number of vegetables or vegetable substances, as well as in the flour of wheat. Rouelle, the younger, showed that it exists in the green fecula of plants; and Proust found it in the following grains and fruits: Peas, Beans, Barley, Rye, Acorns, Chesnuts, Horse-Chesnuts, Apples, Quinces, Elder-berries, Grapes. He found it also in the leaves of Rue, Cabbage, Cresses, Hemlock, Borage, and Saffron, and in the petals of the rose.

Uses.

It is unquestionably one of the most important of all vegetable substances, as being the principle that renders the flour of wheat so fit for forming bread, by its occasioning the panary fermentation, and making the bread light and porous. It is used also as a cement, and capable of being used as a varnish, and a ground for paint.

SECTION V.

Albumen.

Proved to exist in vegetables.

Albumen, which is a thick, glary, and tasteless fluid resembling the white of an unboiled egg, is a substance that has been but lately proved to exist in the vegetable kingdom. Its existence was first announced by Fourcroy, and finally demonstrated by the experiments of Vauquelin on the dried juice of the Papaw-tree, a plant indigenous to India and the Isle of France.

Properties. A specimen of this juice, which often exudes from the tree in a viscid and milky state, was brought to Paris by Charpentier, after being evaporated to dryness, and presented to Vauquelin. It was somewhat yellowish and semi-transparent; and its taste was sweetish; but it had no smell. When it was subjected to maceration in cold water, the greater part of it was dissolved. The solution frothed with soap, and was coagulated and rendered white by the addition of nitric acid. When boiled it precipitated white flakes, which were coagulated albumen possessing all the properties by which it is distinguished in animals, disengaging ammonia by burning, and yielding at the same time carbonic acid and water. And hence its relation to animal gluten is established, and the elements of its composition ascertained; which, according to the analysis of Messrs. Gay Lussac and Thenard, are carbon, oxygene, hydrogene, and nitrogene, in the following proportions:

Composition.

Carbon............	52·883
Oxygene............	23·872
Hydrogene..........	7·540
Nitrogene............	15·705
Total	100·

Albumen has not been found in such abundance in any other plant, as in the plant above specified. But it has been found to exist in Mushrooms and some other of the *Fungi*. And the juice of the fruit of *Hibiscus esculentus*, a West Indian plant, is said to contain such a proportion of it as to render it fit to be employed as a substitute for the white of eggs, in clarifying the juice of the Sugar-cane. Almonds also, and other kernels from which emulsions are made, have been found to contain a substance possessing the properties of curd, which resembles albumen very closely.

Uses.

SECTION VI.

Fibrina.

Properties.

From the blood and muscles of animals chemists extract a peculiar substance which they denominate Fibrina. This substance constitutes the fibrous part of the muscles, and resembles gluten in its appearance and elasticity; its taste is insipid. It is insoluble in water, but soluble in acids and perhaps in alkalies. With nitric acid it yields much of nitrogene; and by distillation it yields carbonate of ammonia and oil.

Found in vegetables.

But a substance possessing the same properties has been detected by Vauquelin in the juice of the Papaw-tree. When the inspissated juice of the Papaw-tree was subjected to maceration in water, the greater part of it was dissolved. But there remained a portion that was insoluble. It had a greasy appearance, and became soft and viscid upon exposure to air, assuming a brown colour with a slight degree of transparency. When thrown upon ignited charcoal it melted, exuding drops of grease, accompanied with a noise like that of meat roasting, and producing smoke which had the odour of volatilized fat. It left no residuum. This substance was vegetable fibrina possessing the properties of the fibrina of animals.

SECTION VII.

Extract.

How obtained.

When vegetable substances are macerated in water a considerable portion of them is dissolved; and if the water is again evaporated, the substance held in solution may be obtained in a separate state. This substance is denominated Extract. But it is evident that extract thus obtained will not be precisely the same principle in every different plant; but will vary in its character according to the species producing it, or the soil in which the plant has grown, or some other accidental cause. It was necessary therefore, for the purposes of chemical accuracy, to endeavour to ascertain whether or not there existed in extracts any peculiar and definite principle, independent of such accidental ingredients as have been now alluded to; and which might itself be regarded as the true extractive principle.

With this object in view, Vauquelin commenced a series of experiments chiefly upon the sap and expressed juices of plants, during the process of which he remarked that they always began to acquire a darker shade of colour from the moment they were exposed to the air; and that during their evaporation a brown or reddish pellicle was formed on the surface, which afterwards broke into flakes and remained insoluble. Similar phenomena were found to take place in pharmaceutical extracts, and the longer the evaporation was continued, the more of the insoluble flakes were formed. This was accordingly regarded as a detection of the true extractive principle, and the formation of the pellicle and flakes was found to be the result of its absorption of a portion of the oxygene of the atmosphere, to which it was thus found to have a strong affinity.

Its distinguishing properties are the following. It is soluble in water as it is obtained from the vegetable, but becomes afterwards insoluble in consequence of the absorption of oxygene from the atmosphere. It is soluble in alcohol; and it unites with alkalies, and forms compounds which are soluble in water. When distilled it yields an acid fluid impregnated with ammonia, and seems to be composed principally of hydrogene, oxygene, carbon, and a little nitrogene.

Varieties. Extract, or the extractive principle, is found in a greater or less proportion in almost all plants whatever, and is very generally an ingredient of the sap and bark, particularly in barks of an astringent taste. But still it is not exactly the same in all individual plants, even when separated as much as possible from extraneous substances. It may therefore be regarded as constituting several different species, of which the following are the most remarkable.

Extract of Catechu.—This extract is obtained from an infusion of the wood or powder of catechu in cold water. Its colour is a pale brown; and its taste slightly astringent. It is precipitated from its solution by nitrate of lead, and yields by distillation carbonic and carburetted hydrogene gas, leaving a porous charcoal.

Extract of Senna.—This extract is obtained from an infusion of the dried leaves of *Cassia Senna* in alcohol. The colour of the infusion is brownish, the taste slightly bitter, and the smell aromatic. It is precipitated from its solution by the muriatic and oxymuriatic acids, and when thrown on burning coals consumes with a thick smoke and aromatic odour, leaving behind a spongy charcoal.

Extract of Quinquina.—This extract was obtained by Fourcroy, by evaporating a decoction of the bark of the *Quinquina* of St. Domingo in water, and again dissolving it in alcohol, which finally deposited by evaporation the peculiar extractive. It is insoluble in cold water; but very soluble in boiling water; its colour is brown, and its taste bitter. It is precipitated from its solution by lime water, in the form of a red powder; and when dry it is black and brittle, breaking with a polished fracture.

Extract of Saffron.—This extract is obtained in great abundance from the summits of the pistils of *Crocus sativus,* which are almost wholly soluble in water.

Uses.

Extracts were formerly much employed in medicine; though their efficacy seems to have been over-rated. But a circumstance of much more importance to society is that of their utility in the art of dyeing. By far the greater part of colours used in dyeing are obtained from vegetable extracts, which have a strong affinity for the fibres of cotton or linen, with which they enter into a combination that is rendered still stronger by the intervention of mordants.

SECTION VIII.

Colouring Matter.

A peculiar substance.

The beauty and variety of the colouring of vegetables has always been the subject of the admiration of mankind. What is the cause of that beauty and variety? Chemists have ascribed it to the modifications of a peculiar substance which they denominate the colouring principle, and which they have accordingly endeavoured to isolate and extract; first by means of maceration or boiling in water, and then by precipitating it from its solution.

Properties. The chemical properties of colouring matter seem to be, as yet, but imperfectly known, though they have been considerably elucidated by the investigations of Bertholet, Chaptal, and others. Its affinities to oxygene, alkalies, earths, metallic oxides, and cloths fabricated whether of animal or vegetable substances, such as wool or flax, seem to be among its most striking characteristics. But its affinity to animal substances is stronger than its affinity to vegetable substances; and hence wool and silk assume a deeper dye, and retain it longer, than cotton or linen. Colouring matter exhibits a great variety of different tints as it occurs in different species of plants; and as it combines with oxygene, which it absorbs from the atmosphere, it assumes a deeper shade. But it loses at the same time a portion of its hydrogene, and becomes insoluble in water; and thus it indicates its relation to extract.

Species. Such are the general properties of colouring matter. But chemists have also instituted specific differences. Bucquet instituted a distinction by which colours were divided into the extractive or soapy, the earthy, the resinous, and the oily; and Fourcroy reduced them also to the four following sorts: extractive colours, oxygenated colours, carbonated colours, and hydrogenated colours: the first being soluble in water and requiring the aid of saline or metallic mordants, to fix them upon cloth; the second being insoluble in water, as altered by the absorption of oxygene, and requiring no mordant to fix them upon cloth; the third containing in their composition a great proportion of carbon, but soluble in alkalies; and the fourth containing a great proportion of resin, but soluble in oils and alcohol.*

The foregoing views of the subject are, no doubt, useful to the chemist. But the simplest mode of arrangement, which shall accordingly be here adopted, is that by which the different species of colouring matter are classed according to their effect in the art of dyeing. Now the principal and fundamental colours in the art of dyeing are the blue, the red, the yellow, and the brown.

Blue or indigo.

The finest of all vegetable blues is that which is known by the name of Indigo. It is the produce of the *Indigofera tinctoria* of Linnæus, a shrub which is cultivated, for the sake of the dye it affords, in Mexico and the West Indies. The plant reaches maturity in about six months, when its leaves are gathered and immersed in vessels filled with water till fermentation takes place. The water then becomes opaque and green, exhaling an odour like that of volatile alkali, and evolving bubbles of carbonic acid gas. When the fermentation has been continued long enough, the liquid is decanted and put into other vessels where it is agitated till blue flakes begin to appear. Water is now poured in, and the flakes are precipitated in the form of a blue powdery sediment, which is obtained by decantation; and which, after being made up into small lumps and dried in the shade, is the Indigo of the shops.

---

* Connais. de Chem. vol. viii. p. 67.

It is insoluble in water, though slightly soluble in alcohol. But its true solvent is sulphuric acid, with which it forms a fine blue dye, known by the name of liquid blue. It affords by distillation carbonic acid gas, water, ammonia, some oily and acid matter, and much charcoal; whence its constituent principles are most probably carbon, hydrogene, oxygene, and nitrogene.

Indigo may be procured also from several other plants besides *Indigofera tinctoria*, and particularly from *Isatis tinctoria* or Woad, a plant indigenous to Britain, and thought to be the plant with the juice of which the ancient Britons stained their naked bodies to make them look terrible to their enemies. If this plant is digested in alcohol, and the solution evaporated, white crystalline grains, somewhat resembling starch, will be left behind; which grains are Indigo, becoming gradually blue by the action of the atmosphere. The blue colour of Indigo therefore is owing to its combination with oxygen.

Red.

The principal red colours are such as are found to exist in the root, stem, or flower, of the five following plants: 1st, From the roots and stems of *Rubia tinctorum* dried, bruised, and sifted, a powder is obtained that is soluble in alcohol, and partly soluble in water, and dyes cloth, by means of proper mordants, either violet or red. Its red is very beautiful, and it possesses also the singular property of dyeing the bones of animals of a red colour when mixed with their food.* 2dly, From *Lichen Roccella* and *parellus*, dried and reduced to a powder, and then macerated in water, a red precipitate is obtained by muriate of tin that forms a beautiful but perishable dye. But when it is applied to marble it stains it of a beautiful violet that is permanent for years. 3dly, From the flowers of the *Carthamus tinctorius* when treated with alkalies, a red colouring matter is extracted, which is precipitated by means of acids, and from which the rouge used by ladies is said to be manufactured, by mixing it with the powder of talc. 4thly, From *Cæsalpinia crista*, generally known by the name of Brazil wood, a colouring matter is also obtained that dyes stuffs red that have been first impregnated with alum, and forms lakes that are employed in painting on paper. 5thly, From *Hæmatoxylon campechianum*, or wood of Campechy, a red colouring matter is obtained resembling that of Brazil wood, except that its shade is somewhat deeper and more permanent. It is much employed in dyeing silks.

---

* Du Hamel, Phys. des Arb. liv. v. chap. ii.

Yellow. Yellow, which is a colour of very frequent occurrence among vegetables, and the most permanent among flowers, is extracted, for the purpose of dyeing, from a variety of plants. 1st, It is extracted from the *Reseda luteola* of Linnæus, by the decoction of its dried stems. The colouring matter is precipitated by means of alum, and is much used in dyeing wool, silk, and cotton. 2dly, It is obtained from the *Morus tinctoria,* a native of the West India Islands, by means also of decoction. The decoction dyes cloth yellow without the intervention of any mordant, and throws down a yellow precipitate if mixed with acids. 3dly, It is obtained from the *Bixa orellana,* a tree that grows in South America, and produces fruit twice in the year. The seeds are bruised and kneaded with a little oil into a paste known by the name of *rocou*; from the decoction of which in water, or solution in alkalies, it is precipitated by alum, with which it forms a yellow lake. 4thly, It is obtained by similar processes from the following plants also: *Serratula tinctoria*, *Genesta tinctoria, Rhus Cotinus, Rhamnus infectorius,* and *Quercitron*, the bark of which last affords a rich and permanent yellow, that is at present much in use.

Brown. The colouring matter of vegetables that gives a brown dye to cloths is very abundant, particularly in astringent plants. It is obtained from the root of the Walnut-tree, and rind of the Walnut; as also from the Sumac and Elder, but chiefly from Nut-galls; which are excrescences formed upon the leaves of a species of *Quercus* indigenous to the South of Europe, in consequence of the puncture of insects. The best in quality are brought from the Levant. They are sharp and bitter to the taste, and extremely astringent; and soluble in water by decoction when ground or grated to a powder. The decoction strikes, with the solution of iron, a deep black that forms the basis of ink, and of most dark colours used in dyeing cloths.

SECTION IX.

Tannin.

How obtained.

IF a quantity of pounded Nut-galls, or bruised seeds of the Grape, is taken and dissolved in cold water, and the solution evaporated to dryness, there will be left behind a brittle and yellowish substance of a highly astringent taste, which substance is tannin, or the tanning principle.

Properties.

It is soluble both in water and alcohol, but insoluble in ether. With the salts of iron it strikes a black. And when a solution of gelatine is mixed with an aqueous solution of tannin, the tannin and gelatine fall down in combination, and form an insoluble precipitate.

HALLIDIE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

When tannin is subjected to the process of distillation it yields charcoal, carbonic acid, and inflammable gases, with a minute quantity of volatile alkali, and seems accordingly to consist of the same elements with extract, from which, however, it is distinguished by the peculiar property of its action upon gelatine.

Varieties.

Chemists have enumerated several obvious varieties or species of tannin, which seem to be founded chiefly on the peculiar colour of their precipitate by gelatine. The first and purest species is that which is obtained from the seeds of the Grape.* It forms a white precipitate with the solution of isinglass; and is approximated in its qualities by the tannin of *Nut-galls,* which is regarded, however, as constituting a second species. The tannin of *Catechu* is a third species. Its precipitate by gelatine is distinguished by a tint of brown. A fourth species is obtained from *Pterocarpus Draco*, *Dracæna Draco*, and *Calamus Draco,* generally denominated *Dragon's-blood.* A fifth species is obtained from *Rhus coriaria* or Sumac, by drying and grinding the shoots of the plant to a powder. Its precipitate by gelatine remains in the state of a white magma, or sediment without consistence. A sixth species is obtained from the wood of the *Morus tinctoria,* by means of maceration in water or in alcohol. It is precipitated even by a solution of common salt. A seventh is obtained from the common Kino of the shops, which is an extract from the *Cocoloba urifera.* Its solution throws down gelatine of a rose colour, and forms with salt of iron a deep green precipitate.

---

* Davy's Elem. of Agri. Chem. p. 78.

Plants containing it.

Tannin may be obtained from a great variety of other vegetables also, as well as those already enumerated, but chiefly from their bark; and of barks, chiefly from those that are astringent to the taste. The following table exhibits a general view of the relative value of different species of barks, as ascertained by Sir Humphry Davy.* It gives the average obtained from 480lb. of the entire bark of a middle-sized tree of the several different species, taken in the spring, when the quantity of tannin is the largest.

	lb.		lb.
Oak	29	Sycamore	11
Spanish Chesnut	21	Lombardy Poplar	15
Leicester Willow (large)	33	Birch	8
Elm	13	Hazel	14
Common Willow (large)	11	Black Thorn	16
Ash	16	Coppice Oak	32
Beech	10	Inner rind of Oak bark	72
Horse Chesnut	9	Oak cut in autumn	21

Uses.

Tannin, which is regarded by chemists as being the general principle of astringency, has been found to be of the very first utility in its application to medicine. The medical virtues of Peruvian

---

* Elem. of Agri. Chem. p. 79.

Bark, so celebrated as a febrifuge and antiseptic, are supposed to depend upon the quantity and quality of its tannin. But it is also of special utility in its application to the arts, in consequence of its peculiar property of forming an insoluble compound with gelatine, by means of which the hides of animals are converted into leather, and on which the important art of tanning wholly depends. The bark of the Oak-tree, which contains tannin in great abundance, is that which is most generally used by the tanner. The hides to be tanned are prepared for the process by steeping them in lime-water, and scraping off the hair and cuticle. They are then soaked first in weaker infusions, and afterwards in stronger infusions of the bark, till at last they are completely impregnated. This process requires a period of from ten to eighteen months, if the hides are thick; and four or five pounds of bark are necessary on an average, to form one pound of leather.

SECTION X.

Bitter Principle.

A peculiar substance.

THE taste of many vegetables, such as those employed in medicine, is extremely bitter. The Quassia of the shops, the roots of common Gentian, the bark and wood of common Broom, the calyx and floral leaves of the Hop, and the leaves and flowers of Chamomile, may be quoted as examples.

This bitter taste has been thought to be owing to the presence of a peculiar substance, different from every other vegetable substance, and has been distinguished by the name of the Bitter Principle.

Properties.

When water has been digested for some time over Quassia, its colour becomes yellow, and its taste intensely bitter; and if it is evaporated to dryness, it leaves behind a substance of a brownish yellow, with a slight degree of transparency, that continues for a time ductile, but becomes afterwards brittle. This substance Dr. Thomson regards as the bitter principle in a state of purity.*

It is soluble in water and in alcohol; but the solution is not much affected by re-agents. Nitrate of silver, and acetate of lead, are the only two that occasion a precipitate.

Uses.

The Bitter Principle is of great importance, not only in the practice of medicine, but also in the art of brewing, particularly as it is obtained from the hop, its influence being that of checking fermentation, preserving the fermented liquor, and communicating to it a peculiar and agreeable flavour. It appears to consist principally of carbon, hydrogene, and oxygene, with a little nitrogene.†

---

* Thomson's Chemistry, vol. iv. p. 242.

† Elem. of Agri. Chem. p. 84.

SECTION XI.

Narcotic Principle.

Whence obtained.

THERE is a species of medical preparations known by the name of Narcotics, which have the property of inducing sleep; and if administered in large doses, of occasioning death. They are obtained from the milky and proper juices of some vegetables, and from the infusion of the leaves or stem of others, all which have been supposed to contain in their composition some common ingredient, which chemists have agreed to designate by the name of the Narcotic Principle. It exists in great abundance in Opium, which is the concrete juice of *Papaver album* or the White Poppy, from which it is obtained pure in the form of white crystals.

Properties.

It is soluble in boiling water and in alcohol, as well as in all acid menstrua; and it appears that the action of opium on the animal subject depends on this principle. When distilled it emits white vapours, which are condensed into a yellow oil. Some water and carbonate of ammonia pass into the receiver; and at last carbonic acid gas, ammonia, and carburetted hydrogen, are disengaged, and a bulky charcoal left behind.

Many other vegetable substances besides opium possess narcotic qualities, though they have not yet been minutely analyzed. The following are the most remarkable: the inspissated juice of Lettuce, which resembles opium much in its appearance, is obtained by the same means, and possesses the same medical virtues; the leaves of *Atropa Belladonna* or Deadly Nightshade, and indeed the whole plant; the leaves of *Digitalis purpurea* or Foxglove; and lastly the following plants, *Hyoscyamus niger, Conium maculatum, Datura Stramonium*, and *Sedum palustre;* with many others belonging to the natural order of Luridæ.

SECTION XII.

Acids.

Contained in vegetables.

Acids are a class of substances that may be distinguished by their exciting on the palate the sensation of sourness. They exist not only in the animal and mineral, but also in the vegetable kingdom; and such of them as are peculiar to vegetables have been denominated vegetable acids. Of acids peculiar to vegetables chemists enumerate the following: the oxalic, acetic, citric, malic, gallic, tartaric, benzoic, and prussic, which exist ready formed in the juices or organs of the plant, and are accordingly denominated native acids; together with the mucous, pyromucous, pyrotartarous, pyrolignous, camphoric, and suberic, which do not exist ready formed in the plant, and are hence denominated artificial acids. They are consequently not within the scope of the object of the present work.

SUBSECTION I.

Oxalic Acid.—If the expressed juice of the *Oxalis acetosella* is left to evaporate slowly, it deposits small crystals of a yellowish colour and saltish taste, which are known by the name of the acidulum of Sorrel, that is, a salt with excess of acid, from which the acid may be obtained pure by processes well known to the chemist.

Oxalic acid, in its state of purity, is always concrete. Its taste is sharp and acrid. It is readily soluble in cold water, and is distinguished from other acids by its property of decomposing all calcareous salts, and forming with lime a salt insoluble in water. Hence it is used by chemists as a test to detect the presence of calcareous salts. But it is not used in medicine or the arts except in its state of acidulum, in which it is employed to make a sort of lemonade, and to discharge stains of ink. It has been found also in *Oxalis corniculata, Geranium acidum*, in the several species of *Rumex*, and in the pubescence of *Cicer arietinum.*

SUBSECTION II.

Acetic Acid.—The Acetic Acid or vinegar, which is generally manufactured from wine in a certain stage of fermentation, has been found also ready formed in the sap of several trees as analysed by Vauquelin; and also in the acid juice of the *Cicer arietinum*, of which it forms a constituent part. It was obtained also by Scheele from the sap of the *Sambucus nigra*; and is consequently to be regarded as a native vegetable acid. It is distinguished from other vegetable acids by its forming soluble salts with the alkalies and earths.

SUBSECTION III.

Citric Acid.—Citric Acid is the acid that exists in the juice of Lemons. Its taste is very sour in a state of purity, but exceedingly pleasant when diluted with water. By a red heat it yields carbonic acid gas and carbonated hydrogene gas, and is reduced to a charcoal: nitric acid converts it into oxalic and acetic acid, and with lime it forms a salt insoluble in water.

It is much used in the state of Lemon-juice to give a seasoning to liquors, which it does equally well in its concentrated state also. It has been found unmixed with other acids in the following vegetable substances: in the juice of Oranges and Lemons, and in the berries of *Vaccinium Oxycoccus, Vitis Idæa, Prunus Padus, Solanum Dulcamara,* and *Rosa canina.* It has been found also in many other fruits, mixed with other acids.

SUBSECTION IV.

Malic Acid.—Malic Acid is found chiefly in the juice of unripe Apples, whence it derives its name. But it is found also in the juice of Berberries, Elderberries, Gooseberries, Plums, and common House-leek. It cannot be obtained in a crystallized and solid form; but if left exposed to the air it becomes thick and viscous. It is decomposed by heat and by strong acids. Nitric acid converts it into oxalic acid. It combines with alkalies and several of the metals; and forms with lime a soluble salt, by which test it is distinguished from other acids. It has been used hitherto only for the purpose of chemical experiment.

SUBSECTION V.

Gallic Acid.—Gallic Acid, as it is obtained in the greatest abundance, so it derives its name from the nut-gall, from which it may be extracted by the following expeditious process of Deyeux.

Expose a quantity of the powder of nut-galls to a moderate heat, in a glass retort; and the acid will sublime and form crystals of an octahedral figure.

Its taste is austere and astringent. It strongly reddens vegetable blues. It is soluble both in water and alcohol; and is distinguished by its property of communicating to solutions of iron a deep purple colour. When exposed to a gentle heat it sublimes without alteration, but a strong heat decomposes it. Nitric acid converts it into the malic and oxalic acids.

It is of great utility in the art of dyeing, and forms the basis of all black colours and of colours with a dark ground. It forms also the basis of ink; and chemists use it as a test to detect the presence of iron.

SUBSECTION VI.

Tartaric Acid.—If wine is kept for a length of time in a cask or other close vessel, a sediment is precipitated which adheres to the sides or bottom, and forms a crust known by the name of tartar, which is a combination of potass and a peculiar acid in excess. The compound is tartarite of potass, and the acid in its state of purity is the tartaric acid.

It is characterized by the property of its forming with potass a salt that is soluble with difficulty.

It has been found in the following vegetable substances also: in the pulp of Tamarinds, in the juice of the Grape, and Mulberries, Sorrel, and Sumac; and the roots of *Triticum repens*, and *Leontondon Taraxacum.* It is not much used except among chemists. But the tartarite from which it is usually obtained is well known for its medical virtues under the name of Cream of Tartar.

SUBSECTION VII.

Benzoic Acid.—From the Styrax Benzoe, a tree which grows in the Island of Sumatra, there exudes a resinous substance known in the shops by the name of Benzoin, and in which the benzoic acid is contained. It is distinguished from the other acids by its aromatic odour and extreme volatility.

It has been obtained also from the balsams of Tolu and Storax; and is used in pharmacy, in the preparation of boluses and electuaries.

SUBSECTION VIII.

Prussic Acid.—The Prussic Acid is generally classed among the animal acids, because it is obtained in the greatest abundance from animal substances. But it has been proved to exist in vegetable substances also, and is procured by distilling Laurel leaves, or the kernels of the Peach and Cherry, or Bitter Almonds.

When pure it exists in the form of a colourless fluid, with an odour resembling that of Peach-tree blossoms. It does not redden vegetable blues. But it is characterized by its property of forming a blueish green precipitate when it is poured, with a little alkali added to it, into solutions containing iron.

SUBSECTION IX.

General Remarks.—From the experiments that have been made upon vegetable acids it appears that all of them contain carbon, oxygene, and hydrogene, in one proportion or other; and that the prussic acid contains also a portion of nitrogene. The gallic acid contains more of carbon than any other vegetable acid, and the oxalic more of oxygene.

Composition of vegetable acids.

SECTION XIII.

Oils.

VEGETABLE OILS are of two kinds, the fixed and the volatile. The former are not suddenly affected by the application of heat; the latter are very inflammable.

Their division.

SUBSECTION I.

Fixed Oils.—Fixed oils are but seldom found, except in the seeds of plants, and chiefly in such as are dicotyledonous. They are found also, though rarely, in the pulp of fleshy fruits, as in that of the Olive, which yields the most abundant and valuable species of all fixed oils. But dicotyledonous seeds which contain oil, contain also, at the same time, a quantity of mucilage and fecula, and form when bruised in water a mild and milky fluid known by the name of

In what plants found.

emulsion. And on this account they are sometimes denominated emulsive seeds.

Methods of obtaining them. Some seeds yield their oil merely by means of pressure, though it is often necessary to reduce them first of all to a sort of pulp, by means of pounding them in a mortar. Others require to be exposed to the action of heat, which is applied to them by means of pressure between warm plates of tin; or of the vapour of boiling water; or of roasting before they are subjected to the press.

But the oil which is thus expressed is still mixed or combined with other substances, such as fecula, starch, mucilage, which sometimes subside spontaneously if the liquid is kept in a state of repose; first the grosser parts, such as the fragments of parenchyma that may have been expressed along with the oil; then the green fecula, then the starch, and lastly the mucilage. The oil is now left in a state of tolerable purity, but not yet without a mixture of other substances; to divest it of which chemists employ a variety of processes.

Properties. Fixed oil, when pure, is generally a thick and viscous fluid, of a mild or insipid taste, and without smell. But it is never entirely without some colour, which is for the most part green or yellow. Its specific gravity is to water as 9·403 to 1·000.* It is insoluble in water. It is decomposed by the acids, but with the alkalies it forms soap. When exposed to the atmosphere it becomes inspissated and opaque, and assumes a white colour and a resemblance to fat. This is in consequence of the absorption of oxygene; but owing to the appearance of a quantity of water, in oil that is exposed to the action of the air, it has been thought that the oxygene absorbed by it is not yet perhaps assimilated to its substance. When exposed to cold it congeals and crystallizes, or assumes a solid and granular form; but not till the thermometer has indicated a degree considerably below the freezing point. When exposed to the action of heat it is not volatilized till it begins to boil, which is at 600° of Fahrenheit. By distillation it is converted into water, carbonic acid, and carburetted hydrogene gas, and charcoal; the product of its combustion is nearly the same; and hence it is a compound of carbon, oxygene, and hydrogene.

---

* Connaiss. Chim. vol. vii. p. 325.

Genera.

Fixed oils are generally divided into two sorts—fat oils, and drying oils. The former are readily inspissated by the action of the air, and converted into a sort of fat. The latter are capable of being dried by the action of the air, and converted into a firm and transparent substance.

Fat oils.

The principal species of fat oils are the following: 1st, Olive oil, which is expressed from the pulpy part of the fruit of *Olea europea* or the Olive, a shrub that grows naturally in the South of Europe. The fruit is first broken in a mill, and reduced to a sort of paste. It is then subjected to the action of a press, and the oil which is now easily separated swims on the top of the water in the vessel beneath. It is manufactured chiefly in France and in Italy, and is much used throughout Europe to give a seasoning to food. 2dly, Oil of Almonds, which is extracted from the fruit of the *Amygdalus communis* or common Almond, a tree that grows also naturally in the South of Europe. The Almonds are first well rubbed or shook in a coarse bag or sack to separate a bitter powder which covers their epidermis. They are then pounded to a paste in mortars of marble, which is afterwards subjected to the action of a press; and the oil is now obtained as in the case of the Olive. 3dly, Rapeseed Oil, which is extracted from the *Brassica Napus* and *campestris*. It is less fixed and less liable to become rancid than the two former, and is manufactured chiefly in Flanders. 4thly, Oil of Behen, which is extracted from the fruit of the *Guilandina Mohringa*, common in Egypt and Africa. It is apt to become rancid; but it is without odour, and is on this account much used in perfumery.

Drying oils.

The principal species of drying oils are Linseed oil, Nut oil, Poppy oil, and Hempseed oil. 1st, Linseed oil is obtained from the seeds of Flax, which are generally roasted before they are subjected to any other process, for the purpose of drying up their mucilage and separating more oil. The oil is much used in the composition of paints; and with the oxide of lead it is employed by chemists as a lute. 2dly, Nut oil is extracted from the fruit of *Corylus* *avellana,* or *Juglans regia,* the Hazel-nut, or Walnut. The kernel is first slightly roasted, and the oil then expressed. It is used in paintings of a coarser sort; and also in the seasoning of food by many of the inhabitants of the middle departments of France; but it is apt to become rancid. 3dly, Poppy oil is extracted from the seeds of *Papaver somniferum,* which is cultivated in France for this purpose. It is clear and transparent, and dries readily; and when pure it is without taste or odour. It is used for the same purposes as the Olive oil, for which it is often sold, and possesses nothing of the narcotic properties of the Poppy. 4thly, Hemp-seed oil is extracted from the seed of the Hemp. It has a harsh and disagreeable taste, and is used only by painters.

SUBSECTION II.

Volatile Oils.—Volatile Oils, which are known also by the name of essential oils, are of very common occurence in the vegetable kingdom, and are found in almost all the different organs of the plant. They are found in many roots, to which they communicate a fragrant and aromatic odour, with a taste somewhat acrid. The roots of *Inula Helenium, Genista canariensis,* and a variety of other plants, contain essential oils. They are found also in the bark, as in that of *Laurus Cinamomum;* in the wood, as in that of *Laurus Sassafras* and

Whence obtained.

Pinus; in the leaves of labiate plants, such as Mint, Rosemary, Marjoram; and of the odorous *Umbelliferæ*, such as Chervil, Fennel, Angelica; and of plants with compound flowers, such as Wormwood. They are found also in the flower itself, as in the flowers of Chamomile and the Rose; and in the fruit, as in that of Pepper and Ginger; and in the external integuments of many seeds, but never in the cotyledon. They are extracted by means of expression or distillation, and are extremely numerous; and perhaps every plant possessing a peculiar odour possesses also a peculiar and volatile oil. The aroma of plants therefore, or the substance from which they derive their odour, and which is cognizable only by the sense of smell, is perhaps merely the more volatile and evaporable part of their volatile oil, disengaging itself from its combinations.

Properties and uses.

Volatile oils are characterized by their strong and aromatic odour, and rather acrid taste. They are soluble in alcohol, but are not readily converted into soaps by alkalies. They are very inflammable, and are volatilized by a gentle heat. Like fixed oils their specific gravity is generally less than that of water, on the surface of which they will float; though in some cases it is found to be greater than that of water, in which they consequently sink. They are much in request on account of their agreeable taste and odour, and are prepared and sold by apothecaries or perfumers, under the name of distilled waters or essences; as well as employed also in the manufacture of varnishes and pigments.

SECTION XIV.

Wax.

ON the upper surface of the leaves of many trees there may often be observed a sort of varnish, which when separated by certain chemical processes is found to possess all the properties of bees'-wax, and is consequently a vegetable wax.

It exudes, however, from several other parts of the plant besides the leaf, and assumes a more waxy and concrete form, as from the catkins of the Poplar, the Alder, and the Fir; from the fruit of the *Myrica cerifera* and *Croton sebiferum;* but particularly from the antheræ of the flowers, from which it is probable that the bees extract it unaltered. It was the opinion of Reaumur, however, that the pollen undergoes a digestive process in the stomach of the bee before it is converted into wax, though a late writer on the subject endeavours to prove that the wax is elaborated from the honey extracted by the bee, and not from the pollen.* It is found also in the interior of many seeds, from which it is extracted by means of pounding them and boiling them in water. The wax is melted and swims on the top.

---

* Huber, Linnæan Trans. vol. iv.

Properties. Wax, when pure, is of a whitish colour, but without taste and without smell. The smell of bees'-wax is indeed somewhat aromatic, and its colour yellow. But this is evidently owing to some foreign substance with which it is mixed, because it loses its smell and colour by means of bleaching, and becomes perfectly white. This is done merely by drawing it out into thin stripes, and exposing it for some time to the atmosphere. Bleached wax is not affected by the air. Its specific gravity is 0·9600.*

It is insoluble in water, and in alcohol. It combines with the fixed oils, and forms with them a composition known by the name of *Cerate.* It combines also with the fixed alkalies, and forms with them a compound possessing the properties of common soap. The acids have but little action on it, and for this reason it is useful as a lute to confine them, or to prevent them from injuring cork.

When heat is applied to wax it becomes soft, and melts at the temperature of 142° if unbleached, and of 155° if bleached, into a colourless and transparent fluid, which, as the temperature diminishes, concretes again and resumes its former appearance. At a higher temperature it boils and evaporates, and the vapour may be set on fire by the application of a red heat. Hence its utility in making candles. And hence an explication of the singular phenomenon observable in the *Dictamnus Fraxinella.* This plant is fragrant, and the odour which it diffuses around forms a partial and temporary atmosphere which is inflammable; for if a lighted candle or other ignited body is brought near to the plant, especially in the time of drought, its atmosphere immediately take fire. This phenomenon was first observed by the daughter of the celebrated Linnæus, and is explained by supposing the partial and temporary atmosphere to contain a proportion of wax exuded from the plant, and afterwards reduced to vapour by the action of the sun. The result of its combustion in oxygene gas was, according to Lavoisier, carbonic acid and water, in such proportion as to lead him to conclude that 100 parts of wax are composed of 82·28 of carbon and 17·72 of hydrogene. But owing to the little action of acids upon it, there seems reason to believe that it contains also oxygene as an ingredient.*

---

* Thomson's Chemistry, vol. iv. p. 299.

Wax possesses all the essential properties of a fixed oil. But fixed oils have the property of becoming concrete, and of assuming a waxy appearance when long exposed to the air, in consequence, as it seems, of the absorption of oxygene. Wax therefore may be considered as a fixed oil rendered concrete, perhaps, by the absorption of oxygene during the progress of vegetation.

But if this theory is just, the wax may be expected to occur in a considerable variety of states according to its degree of oxygenation; and this is accordingly the case. Sometimes it has the consistency of butter, and is denominated Butter of Wax, as Butter of Coco, Butter of Galam. Sometimes its consistency is greater, and then it is denominated tallow, as Tallow of Croton; and when it has assumed its last degree of consistency it then takes the appellation of wax. The following are its principal species: Butter of Cacao, Butter of Coco, Butter of Nutmeg, Tallow of Croton, and Wax of Myrtle.

---

* Thomson's Chemistry, vol. iv. p. 302.

Species.

1st, The Butter of Cacao is extracted from the seeds of the *Theobroma Cacaco* or Chocolate-plant, either by boiling them in water, or by subjecting them to the action of the press after having exposed them to the vapour of boiling water. They yield almost half their quantity of butter. It is at first brown or yellow, but when well purified it is white. Its taste is sweet, its fracture slightly granular, and its touch unctuous. It is to this butter that chocolate owes its flavour and unctuosity.

2dly, Butter of Coco is found in the fruit of the *Cocos nucifera* or Coco-nut-tree. It is expressed from the pulp of the nut, and is even said to separate from it when in a fluid state as cream separates from milk.*

3dly, Butter of Nutmeg is obtained from the seeds of the *Myristica officinalis* or Nutmeg-tree. They are pounded and formed into a paste with water, and then subjected to the action of the press. The butter is firm and orange-coloured, and of a sweet and aromatic smell.

---

* Fourcroy, vol. vii. p. 347.

4thly, From the *Croton sebiferum*, a tree that grows in China and America, a waxy substance is extracted, of the consistency of tallow. It adheres to the surface of the fruit, and is detached from it by means of boiling the fruit in water. Its odour, which is rather agreeable, had induced some of the people employed in the laboratory of Fourcroy to try it as a seasoning to Spinage. But its effects were found to be violently purgative. The Chinese manufacture it into candles.

5thly, The Wax of Myrtle is obtained from the *Myrica cerifera*, a plant which grows abundantly in Louisiana and other parts of North America. The plant produces a berry about the size of a Peppercorn. The berries are gathered and thrown into a kettle that is nearly filled with water. The kettle is then made to boil, and the wax which is melted out swims on the surface. It is of a pale green colour. Its specific gravity 1·0150. It melts at the temperature of 109°, and when strongly heated burns with a white flame, producing smoke and emitting an agreeable odour.

Wax is also extracted from a variety of other vegetables, and has heen detected by Proust in the green fecula of many plants, as in that of the Cabbage. He considers it as a constituent part of the pollen of all flowers, and thinks that the bees collect it along with the gluten of the pollen, which, according to him, serves them for food.

Certainly it is one of the most abundant of vegetable principles, and is of great utility both in medicine and the arts. Its soft and unctuous qualities render it fit for being employed as an ingredient in ointments and plasters, and in a great variety of pharmaceutic preparations. It is employed also by the sculptor, statuary, and modeller, in the exercise of their arts. But its chief utility consists in its being better adapted than all other substances for the manufacture of candles. The candle burns with a clear and brilliant flame, and the wick needs no snuffing.

SECTION XV.

Resins.

RESINS are substances somewhat resembling gum, at least in their external appearance, and often exuding spontaneously from the plant that contains them. They are exemplified in the common resin of the shops, and are considered as holding the same relation to volatile oils as wax holds to fixed oils. They are volatile oils rendered concrete by means of the absorption of oxygene, or rather perhaps by the abstraction of part of their hydrogene.

Properties. Resins are either soft and viscous, or solid and brittle. They have a slight degree of transparency, and their colour is generally yellowish. Their taste is somewhat acrid, but they are without smell when pure. Their specific gravity varies from 1·0180 to 1·2289. They are non-conductors of electricity, and when excited by friction their electricity is negative.

They are insoluble in water; but most of them are soluble in alcohol, and some of them in the fixed oils.

When exposed to heat they melt and afterwards take fire, burning with a strong yellow flame, and evolving a great deal of smoke. If subjected to destructive distillation, the products are carburetted hydrogene, and carbonic acid gas, a small portion of acidulous water, and much empyreumatic oil.

Resins are extremely numerous, like the oils from which they are formed; but the following are the most distinguished:

Species.

Rosin.—From the different species of Pine or Fir-tree, there exudes a juice which concretes in the form of tears. Its extrication is generally aided by means of incisions, and it receives different appellations according to the species from which it is obtained. If it is obtained from the *Pinus sylvestris,* it is denominated common Turpentine; from *Pinus Larix,* Venice Turpentine; from *Amyris Balsamea,* Balsam of Canada. It consists of two ingredients, oil of turpentine and rosin. The oil is extricated by distillation, and the rosin remains behind. If the distillation is continued to dryness, the residuum is *common rosin* or *colophonium*; but if water is mixed with it while yet fluid, and incorporated by violent agitation, the residuum is yellow rosin. The yellow rosin is the most ductile, and the most generally used in the arts.

From the resinous juices of the Fir, the substances known by the name of pitch and tar are also manufactured. The trunk is cut or cleft into pieces of a convenient size, which are piled together in heaps and covered with turf. They are then set on fire, and the resinous juice which is thus extricated, being prevented from escaping in a volatile state by means of the turf, is precipitated and collected in a vessel beneath. It is partly converted into an empyreumatic oil, and is now tar, which by being further inspissated is converted into pitch.

Mastich.—This resin is extracted from the *Pistacea Lentiscus*, a tree which grows plentifully in the island of Chios. It exudes in a fluid state from incisions made in the stem, and concretes into brittle grains somewhat yellowish and semi-transparent. In this state it is sold under the name of mastich. It has scarcely any taste, but when heated it melts and exhales a fragrant odour. It is sometimes employed as a varnish.

Sandarach.—This resin is obtained from the *Juniperus communis* or common Juniper, by spontaneous exudation. It concretes in the form of small round tears somewhat brownish and semi-transparent, resembling mastich. It is used also as a varnish.

Elemi.—This resin is extracted from the *Amyris Elemifera*, a tree which grows in North America. It exudes from incisions made in the bark during dry weather, and is left to harden in the sun. It is of a pale yellow colour and strong smell, and is somewhat semi-transparent.

Tacambac.—This resin is the produce of the *Fagara octandra* and *Populus balsamifera.* It is brought from America in large oblong masses wrapped in flag leaves. Its colour is light brown. It is brittle, but easily melted by heat, and it has been found to be soluble in alkalies and nitric acid.

Labdanum.—This resin is obtained from the *Cistus creticus,* a shrub which grows in Candia, and other Grecian islands. The surface of the leaves is covered with a viscid juice, which is collected by means of a sort of rake furnished with thongs of leather, to which the juice adheres. It is afterwards scraped from the thongs with a knife. It is very soft, and always mixed with sand and dust. Its colour is blackish, its odour fragrant, and its taste bitter. When dissolved in alcohol it leaves behind it a little gum. It is employed as an astringent.

Opobalsamum, or Balm of Gilead.—This resin, which has been so much famed for its medical virtues, is the produce of the *Amyris Gileadensis,* a shrub which grows in Judæa and in Arabia; but it is so much valued by the Turks that its importation is prohibited. This is the Balm of Gilead so much celebrated in Scripture. Pliny says it was first brought to Rome by the generals of Vespasian.*

---

* Lib. xii. 25.

It is obtained in a liquid state from incisions made in the bark, and is somewhat bitter to the taste.

Copaiva, or Balsam of Copaiva.—This resin is obtained from the *Copaifera officinalis*, a tree which grows in South America. It exudes from artificial incisions, having at first the consistence of oil, but gradually becoming thick as honey. It is transparent and of a yellow colour, with an agreeable smell, but pungent taste. It is a combination of resin and of volatile oil, which may be separated by distillation with water. It is employed also in medicine.

Dragon's blood.—This resin is obtained from the *Dracæna Draco*, *Pterocarpus Draco,* and *Calamus Rotang*, plants that grow in the East Indies and in Spanish America. Its colour is dark red, but it is without taste. Its fracture is glassy, and its powder crimson. It comes into this country in small masses wrapped in leaves, and is much used as a tooth powder.

Guaiac.—This resin is the produce of the *Guaiacum officinale*, a tree which grows in the West Indies. It exudes spontaneously, or is driven out in a melted state by means of the action of heat. Its colour is green, with some transparency; its consistency brittle; its fracture vitreous. It has scarcely any taste and no smell; but when thrown on burning coals it exhales a fragrant odour. It is used in medicine.

Botany Bay resin.—The resin designated by this name is said to be the produce of the *Acarois resinifera*, a native of New Holland, but found in great abundance about Botany Bay. It was first brought to London about 1799. It is described in Governor Philips's Voyage, and in White's Journal of a Voyage to New South Wales.

Green resin.—This resin constitutes the colouring matter of the leaves of trees and of almost all vegetables. It is insoluble in water, but soluble in alcohol. When treated with oxymuriatic acid it assumes the colour of a withered leaf, and exhibits the resinous properties more distinctly.*

Copal.—This resin is the produce of the *Rhus copallinum*, a tree which is found in North America. It is a transparent substance, with a slight tinge of brown. It possesses the general properties of other resins, but differs from them in not being soluble in alcohol or oil of turpentine, without peculiar management. When dissolved in any volatile liquid and spread thin upon wood, metal, or paper, so that the volatile menstruum may evaporate, it forms one of the most perfect and most beautiful of all varnishes, known by the name of Copal varnish. For this purpose it is generally dissolved in oil of turpentine.

Animé.—This resin is obtained from the *Hymenæa Coubaril*, or Locust-tree, a native of North

---

* Thomson's Chemistry, vol. iv. p. 318.

America. It resembles copal exactly in its appearance; but differs from it in being readily soluble in alcohol. It is employed also in making varnishes.

Lac.—This resin is the produce of the *Croton lacciferum*, a native of the East Indies. It exudes in consequence of the puncture of an insect, whence it is supposed to derive its colour, which is deep red verging on brown, with a degree of semi-transparency. It forms the basis of many varnishes, and of the finest kinds of sealing-wax.

Bloom.—Upon the epidermis of the leaves and fruit of certain species of plants, there is to be found a fine soft and glaucous powder. It is particularly observable upon cabbage leaves, and upon plums, to which it communicates a peculiar shade. It is known to gardeners by the name of *bloom*. It is easily rubbed off by the fingers; and when viewed under the microscope seems to be composed of small opaque and unpolished granules, somewhat similar to the powder of starch; but with a high magnifying power it appears transparent. When rubbed off it is again reproduced, though slowly. It resists the action of dews and rains, and is consequently insoluble in water. But it is soluble in spirits of wine; from which circumstance it has been suspected, with some probability, to be a resin.*

---

* Mirbel, Phys. Veg. vol. i. p. 112.

Such are the most remarkable of the resins that have hitherto been subjected to chemical analysis, or employed in medicine and the arts. Their medical virtues, however, are not quite so great as has been generally supposed; but their utility in the arts is very considerable. They are employed in the arts of painting, varnishing, embalming, and perfumery; and they furnish us with two of the most important of all materials to a naval power, pitch and tar.

SECTION XVI.

Gum-resins.

Whence obtained.

THIS term is employed to denote a class of vegetable substances which have been regarded by chemists as consisting of gum and resin. They are generally contained in the proper vessels of the plant, whether in the root, stem, branches, leaves, flower, or fruit. But there is this remarkable difference between resins and gum-resins, that the latter have never been known, like the former, to exude spontaneously from the plant.* They are obtained by means of bruising the parts containing them, and expressing the juice, which is always in the state of an emulsion, generally white, but sometimes of a different colour; or they are obtained by means of incisions from which the juice flows. This juice, which is the proper juice of the plant, is then exposed to the action of the sun, by which in warm climates it is condensed and inspissated, and converted into the gum-resin of commerce.

---

* Fourcroy, vol. viii. p. 27.

Properties. Gum-resins in their solid state are brittle, and less transparent than resins. They have generally a strong smell, which is sometimes alliaceous, and a bitter and nauseous taste.

They are partially soluble both in water and in alcohol. When heated they do not melt like the resins, nor are they so combustible. But they swell and soften by heat, and at last burn away with a flame. By distillation they yield volatile oil, ammonia combined with an acid, and have a bulky charcoal.*

Species. The following are the principal species of gum-resins which have been hitherto applied to any useful purpose.

Galbanum.—This substance is obtained from the *Bubon Galbanum*, a perennial plant found at the Cape of Good Hope. An incision is made in the stem a little above the root, and the milky juice flows out. When it concretes it constitutes galbanum. It is brought into this country in small pieces composed of agglutinated tears. Its colour is yellow, its taste acrid and bitter, and its odour alliaceous. Water, vinegar, and wine, dissolve the greater part of it, but the solution is milky.

---

* Fourcroy, vol. viii. p. 29.

Its specific gravity is 1·212. It is employed in the composition of ointments and plasters.

Ammoniac.—This substance is brought from Africa in the form of small tears; but nothing certain is known concerning the plant which yields it. It is thought to be a species of *Ferula.* The colour of the substance is yellow, and the taste nauseous. It is used in medicine.

Scammony.—This substance is the produce of the *Convolvulus Scammonia,* a climbing plant which grows in Persia. The root when cut yields a milky juice by expression, which, when it concretes, forms scammony. Its colour is dark grey, its smell nauseous when rubbed, and its taste bitter. It forms with water a green opaque liquid. It is much employed in medicine, and operates as a strong cathartic.

Opoponax.—The plant from which this substance is obtained is the *Pastinaca Opoponax,* a native of the countries of the Levant. It exudes in the state of a milky juice from incisions made in the root. It is afterwards dried in the sun, and is generally to be met with in lumps of a reddish colour, and white within. Its taste is bitter and acrid, and it forms with water a milky solution.

Euphorbium.—This substance is the produce of the *Euphorbia officinalis,* a plant which grows in Africa. It is the milky juice of the plant dried in the sun, and obtained by means of incisions. It assumes the form of small yellow tears. It has no smell; its taste is caustic; it is considered as a poison, but is occasionally employed in medicine.

Olibanum.—This substance is obtained from the *Juniperus lycia,* which grows in Arabia, particularly by the borders of the Red Sea. It is the frankincense of the ancients. It exudes from incisions made in the tree, and concretes into masses about the size of a chesnut. It is brittle, transparent, and of a yellow colour. It has little taste, but when burnt diffuses an agreeable odour.

Sagapenum—The plant from which this substance is obtained is not well known; but it is supposed to be the *Ferula persica.* The substance itself is brought from Egypt, Persia, or India. It is generally in the form of agglutinated tears. Its colour is yellow; its taste hot and bitter; and its smell alliaceous.

Gamboge, or Gumgutt.—This substance is the produce of the *Mangostana Cambogia,** a tree which grows in the East Indies. It exudes from incisions of the bark, and is brought to Europe in large cakes or cylindrical masses. Its colour is yellow, and its fracture vitreous; but it has no smell, and very little taste. It forms with water a yellow turbid liquid, but is soluble almost entirely in alcohol. In medicine it is a violent cathartic.

Myrrh.—It is not yet ascertained from what plant this substance is procured; but it grows in Abyssinia and Arabia: Bruce says it belongs to the genus Mimosa. But however this may be, myrrh is the juice of the plant concreted in the form of tears. Its colour is yellow, its odour strong but agreeable, and its taste bitter. It is employed in medicine, and is esteemed an excellent stomachic.

---

* Ventenat, Tab. du Reg. Veg. vol. iii. p. 146.

Assafœtida.—This substance, which is well known for its strong and fetid smell, is obtained from the *Ferula assafœtida,* a plant which grows in Persia. At four years old the plant is dug up by the root. The root is then cleaned, and the extremity cut off; a milky juice exudes which is collected; and when it ceases to flow another portion is cut off, and more juice extricated. The process is continued till the root is exhausted. The juice which has been collected soon concretes and constitutes assafœtida. It is brought to Europe in small agglutinated grains of different colours, white, red, yellow. It is hard, but brittle. Its taste is bitter, and its smell insufferably fetid; and yet the Indians use it as a seasoning for their food, and call it *the food of the gods.* This forms a strange contrast to the name which it has obtained in Europe, where it is vulgarly known by the appellation of *Devil's dung.* It is used in medicine as an antispasmodic.

SECTION XVII.

Balsams.

THE substances known by the name of balsams are nearly related to the resins and gum-resins. This relation was first pointed out by Bucquet, in 1774, who found them to be resins united to the benzoic acid,* which they yield by means of the action of heat. This latter circumstance is sufficient to entitle them to a separate consideration. They are obtained by means of incisions made in the bark, from which a viscous juice exudes, which is afterwards inspissated by the action of the fire or air; or they are obtained by means of boiling the part that contains them.

How obtained.

They are thick and viscid juices, but become readily concrete. Their colour is brown or red; their smell aromatic when rubbed; their taste acrid; their specific gravity 1·090.

Properties.

They are unalterable in the air after becoming concrete. They are insoluble in water, but boiling water abstracts part of their acid; they are soluble in the alkalies and nitric acid.† When heated, they melt and swell, evolving a white and odorous smoke.

Species.

The principal of the balsams are the following: Benzoin, Storax, Styrax, Balsam of Tolu, Balsam of Peru.

Benzoin.—It was long supposed that this substance was the produce of a species of *Laurus;* but it appears, from the observations of Mr. Dryander, to be the produce of a species of *Styrax,* a tree which grows in Sumatra, and is denominated the *Styrax benzoin.* It flows from incisions made in the trunk, and comes into Europe in masses of a light brown colour, variegated with yellow specks. It is brittle with a vitreous fracture. It is soluble in alcohol. When rubbed it emits a fragrant odour, and when heated it lets the benzoic acid escape. It is made use of to perfume apartments, or to furnish benzoic acid.

---

* Fourcroy, vol. viii. p. 43.

† Thomson's Chemistry, vol. iv. p. 327.

Storax.—This balsam is obtained from the *Styrax officinale*, a tree which grows in France, Italy, and the Islands of the Levant. It is extracted by means of incisions, and concretes into cakes or masses of an irregular form, and a brown or reddish colour. Its taste is spicy, and its smell fragrant: it is employed in perfumery.

Styrax.—This substance is a semi-fluid juice It does not seem to be ascertained of what tree it is the produce. But the tree is said to be cultivated in Arabia, and known to the natives by the name of *rosamallos*. The balsam procured from it is greenish; its taste aromatic; and its smell pleasant. It is a combination of benzoic acid and resin, and is used in pharmacy in the preparation of an ointment.

Balsam of Tolu.—This balsam is obtained from the *Toluifera Balsamum*, a tree of South America. It flows from incisions made in the bark, and is brought to Europe in small gourd shells. Its colour is brown, and its smell fragrant; but its chemical properties have not yet been fully investigated. It is employed in medicine, and is esteemed efficacious in diseases of the lungs.

Balsam of Peru.—This balsam is obtained from the *Myroxylon peruiferum*, a tree which is found in South America. It is extracted by boiling the twigs in water, and put into cocoa-nut shells, in which it is generally brought to Europe. It resembles the balsam of Tolu in its chemical properties as far as they have been hitherto examined, and is applied to the same medical purposes; but its consistency is less solid, and it is more easily volatilized by heat.

SECTION XVIII.

Camphor.

How obtained.

THE substance known by the name of Camphor is the produce of the *Laurus camphorata*, a tree which grows in China and the islands of the East Indies. It is obtained in the following manner: The root and stem of the plant are cut into small pieces and put into a large alembic furnished with a capital and containing some water. When a sufficient heat is applied the camphor sublimes into the capital in the form of small greyish grains which are united into larger masses by means of friction. In this state it is yet impure. But it is afterwards refined by a second sublimation.

Camphor, when pure, is a white brittle substance, forming octagonal crystals or square plates. Its taste is hot and acrid, its odour strong but aromatic, its specific gravity 0·9887.*

When broke into small fragments and put into water, on the surface of which it swims, a singular phenomenon ensues. The water surrounding the fragments is immediately put into commotion, advancing and retiring in little waves and attacking the fragments with violence. The minuter fragments are driven backwards and forwards upon the surface as if impelled by contrary winds. If a drop of oil is let fallen on the surface of the water it produces an immediate calm. This phenomenon has been attributed to electricity. Fourcroy thinks it is merely the effect of the affinities of the camphor, water, and air, entering into combination.*

---

* Thomson's Chemistry, vol. iv. p. 328.

Properties.

It is not altered by exposure to the air; but it is so volatile that it evaporates completely if exposed to it in warm weather. It is insoluble in water, to which however it communicates its peculiar odour. It is soluble in alcohol from which it is again precipitated by water.

It is soluble in acids, and its solution in nitric acid, which is yellow, is known by the name of *oil of camphor*.

It melts at the temperature of 300°;† and is so inflammable that it will burn even on the surface of the water. It burns with a bright flame and leaves no residuum. If formed into a paste with water and alumina, and distilled in a glass retort, the products are volatile oil, camphoric acid, carbonic acid gas, and carburetted hydrogene gas, with a residuum of charcoal and alumina, in such proportion as to warrant the conclusion that the ultimate ingredients of camphor are carbon and hydrogene.*

---

* Connaiss. Chim. vol. viii. p. 9.

† Ibid. vol. viii. p. 10.

Though camphor is obtained chiefly from the *Laurus camphorata*, yet it is known to exist in a great many other plants, particularly labiate plants, and has been extracted from the roots of Zedoary, Sassafras, Thyme, Rosemary, Lavender.

Uses. It is much employed in pharmacy and medicine. It is regarded as a powerful stimulant, and is found to be peculiarly efficacious in urinary disorders. It has been regarded also as a preventive against contagion, if worn about the body and occasionally applied to the organ of smell; but its efficacy in this respect seems doubtful. It is peculiarly offensive to insects, and is consequently of great utility to prevent their depredations in cabinets of natural history. It is used also in the composition of matches and other inflammable materials, particularly if they are to be exposed to the action of water.

SECTION XIX.

Caoutchouc.

How obtained. THE substance denominated Caoutchouc was first introduced into Europe about the beginning of the last century. But from a use to which it is very generally applied of rubbing out the marks made upon paper by a black-lead pencil, it is better known to most people in this country by the name of *Indian rubber.*

---

* Thomson's Chemistry, vol. iv. p. 330.

It is obtained chiefly from *Hævea Caoutchouc* and *Jatropha elastica,* trees indigenous to South America; but it has been obtained also from several trees which grow in the East Indies, such as *Ficus indica, Artocarpus integrifolia* and *Urceola elastica.*

If an incision is made into the bark of any of these plants a milky juice exudes which, when it is exposed to the air, concretes and forms caoutchouc. As the object of the natives in collecting it had been originally to form it into vessels for their own use, it is generally made to concrete in the form of bags or bottles. This is done by applying the juice when fluid in thin layers to a mould of dried clay, and then leaving it to concrete in the sun or by the fire. A second layer is added to the first, and others in succession, till the vessel acquires the thickness that is wanted. The mould is then broken and the vessel fit for use, and in this state it is generally brought into Europe. It has been brought, however, even in its milky state by being confined from the action of the air.*

If the milky juice is exposed to the air, an elastic pellicle is formed on the surface. If it is confined in a vessel containing oxygene gas, the pellicle is formed sooner. If oxymuriatic acid is poured into the milky juice, the caoutchouc precipitates immediately. This renders it probable that the formation of the caoutchouc is owing to the absorption of oxygene.

---

* Connais. Chim. vol. viii. p. 37.

Properties. Caoutchouc, when pure, is of a white colour, without taste and without smell. The black colour of the caoutchouc of commerce is owing to the method of drying the different layers upon the moulds on which they are spread. They are dried by being exposed to smoke. The black colour of the caoutchouc therefore is owing to the smoke or soot alternating with its different layers. It is soft and pliable like leather and extremely elastic, so that it may be stretched to a very great length, and still recover its former size. Its specific gravity is 0·9335. Mr. Gough of Manchester, has made some curious and important experiments on the connexion between the temperature of caoutchouc and its elasticity, from which it results that ductility as well as fluidity is owing to latent heat.*

Caoutchouc is not altered by exposure to the air. It is perfectly insoluble in water; but if boiled in water for some time its edges become so soft that they will cement, if pressed and kept for a while closely together.†

It is insoluble in alcohol, but soluble in ether.‡ It is soluble also in volatile oils and in alkalies. And from the action operated upon it by acids, it is thought to be composed of carbon, hydrogene, oxygene, and azote.§

---

* Manch. Trans. vol. vi.

† Ann. de Chim. vol. xi. p. 153.

‡ Thomson's Chem. vol. iv. p. 337.

§ Ibid.

It seems to exist in a great variety of plants combined with other ingredients. It may be separated from resins by alcohol. It may be separated from the berries of the Misletoe by means of water, and from other vegetable substances by other processes. It is said to be contained both in opium and in mastic.* But from these substances it cannot be extracted in sufficient quantities to make it worth the labour. It is applied to a great many useful purposes both in medicine and the arts, to which, from its great pliability and elasticity, it is uncommonly well adapted. In the countries where it is produced the natives make boots and shoes of it, and often use it by way of candle. Uses.

SECTION XX.

Cork.

THE substance known by the name of Cork is the outer and exfoliated bark of the *Quercus Suber* or Cork-tree, a species of Oak that grows in great abundance in France, Spain, and Italy. But to prevent its natural exfoliation which is always irregular, and to disengage it in convenient portions, a longitudinal incision is made in the bark from the root to the top of the stem; and a transverse and circular incision at each extremity. The outer How manufactured.

---

* Thomson's Chemistry, vol. iv. p. 393.

layer, which is cork, is then stripped off, and to flatten and reduce it to sheets, it is put into water and loaded with weights. The tree continues to thrive, though it is thus stripped of its cork once in two or three years,

Cork is a light, soft, and elastic substance, distinguished by the following properties. Its colour is a sort of light tan. It is very inflammable and burns with a bright white flame, leaving a black and Properties. bulky charcoal behind. When distilled it yields a small quantity of ammonia. Nitric acid corrodes and dissolves it, changing its colour to yellow, and finally decomposes it, converting it partly into an acid, and partly into a soft substance resembling wax or resin. The acid which is thus formed is denominated the Suberic acid, and has been proved by the experiments of Lagrange to be an acid of a peculiar nature.*

It seems probable that cork exists in the bark of some other trees also as well as the *Quercus Suber*. There is a variety of the *Ulmus campestris*, common in hedge-rows, whose bark assumes something of the external appearance of cork, which it resembles in its thickness, softness, and elasticity, and in its loose and porous texture, as well as also in its chemical properties.† Fourcroy seems, indeed, to regard the epidermis of all trees whatever to be a sort of cork, but does not say on what grounds his opinion is founded.

---

* Connais. Chim. vol. viii. p. 98.

† Ibid.

SECTION XXI.

Woody Fibre.

THE principal body of the root, stem, and branches of trees, is designated by the appellation of Wood. But the term is too general for the purpose of analytical distinction, as the part designated by it often includes the greater part of the substances that have been already enumerated. It remains therefore to be ascertained whether there exists in the plant any individual substance different from those already described, and constituting more immediately the fabric of the wood.

How procured.

If a piece of wood is well dried and digested, first in water and then in alcohol or such other solvent as shall produce no violent effects upon the insoluble parts; and if the digestion is continued till the liquid is no longer coloured, and dissolves no more of the substance of the plant, there remains behind a sort of vegetable skeleton, which constitutes the basis of the wood, and which has been denominated Woody Fibre. It is composed of bundles of longitudinal threads, which are divisible into others still smaller. It is somewhat transparent. It is without taste and smell, and is not altered by exposure to the atmosphere. It is insoluble in water and alcohol; but the fixed alkalies decompose it with the assistance of heat. When heated in the open air it blackens without melting

Properties.

or frothing, and exhales a thick smoke and pungent odour, leaving a charcoal that retains the form of the original mass. When distilled in a retort it yields an empyreumatic oil, carburetted hydrogene gas, carbonic acid, and a portion of ammonia, according to Fourcroy, indicating the presence of nitrogene as constituting one of its elementary principles, and yet this ingredient does not appear in the result of the later analysis of Messrs. Gay Lussac and Thenard, which is as follows from experiments on the wood of the Oak:

Composition.

Carbon	52·53
Oxygene	41·78
Hydrogene	5·69
Total	100·

SECTION XXII.

Charcoal.

How procured.

When wood is burnt with a smothered flame, the volatile parts are driven off by the heat, and there remains behind a substance exhibiting the exact form, and even the several layers of the original mass. This process is denominated charring, and the substance obtained, *Charcoal.* As it is the woody fibre alone which resists the action of heat, while the other parts of the plant are dissipated, it is plain that charcoal must be the residuum of woody fibre, and that the quantity of the one must depend upon the quantity of the other, if they are not rather to be considered as the same.

Charcoal may be obtained from almost all parts of the plant whether solid or fluid, and it is rendered perceptible by means of combustion. It often escapes however, during combustion, under the form of carbonic acid, of which it constitutes one of the elements.

From a variety of experiments made on different plants and on their different parts, it appears that the green parts contain a greater proportion of charcoal than the rest. But this proportion is found to diminish in autumn, when the green parts begin to be deprived of their glutinous and extractive juice. The wood contains more charcoal than the alburnum, the bark more than both. But this last result is not constant in all plants because the bark is not a homogenous substance, the outer parts being affected by the air and the inner parts not. The wood of the *Quercus Robur*, separated from the alburnum, yielded from 100 parts of its dried substance 19·75 of charcoal; the alburnum 17·5; the bark 26; leaves gathered in May 80; in September 26.*

Proportion in different plants.

But the quantity of charcoal differs also in different plants, as well as in different parts of the same. In the plants examined by Proust the proportion was found to be as follows, the quantity of wood charred being represented by unity:

---

* Sauss. sur la Veg. chap. v. sect. x.

Black Ash	0·25
Guaiacum	0·24
Pine	0·20
Green Oak	0·20
Heart of Oak	0·19
Wild Ash	0·17
White Ash	0·17

Properties. Charcoal is insoluble in water, of which however it absorbs a portion when newly made, as also of atmospheric air. It is incapable of putrefaction. It is not altered by the most violent heat that can be applied, if all air and moisture are excluded; but when heated to about 800° it burns in atmospheric air or oxygene gas, and if pure, without leaving any residuum. It is regarded by chemists as being a triple compound, of which the ingredients are carbon, hydrogene, and oxygene.

Uses. Charcoal is of great utility both to the chemist and artist as a fuel for heating furnaces, as well as for a variety of other purposes. It is an excellent filter for purifying water. It is a very good tooth powder; and is also an indispensable ingredient in the important manufacture of gunpowder.

SECTION XXIII.

The Sap.

How extracted.

If the branch of a Vine is cut asunder early in the spring before the leaves have begun to expand, a clear and colourless fluid will issue from the wound, which gardeners denominate the tears of the Vine. It is merely, however, the ascending sap, and may be procured from almost any other plant by the same or similar means, and at the same season; but particularly from the Maple, Birch, and Walnut-tree, by means of boring a hole in the trunk. It issues chiefly from the porous and mixed tubes of the alburnum; though sometimes it does not flow freely till the bore is carried to the centre.* A small branch of a Vine has been known to yield from twelve to sixteen ounces, in the space of twenty-four hours. A Maple-tree of moderate size yields about 200 pints in a season, as has been already stated; and a Birch-tree has been known to yield in the course of the bleeding season, a quantity equal to its own weight.

Properties.

The taste of this fluid is generally insipid; but sometimes it is slightly saline, and sometimes agreeably sweet, as in the case of the Birch-tree. If it is agitated but slightly a froth is formed on the surface; and if it is kept for any length of time in a close vessel it ferments and effervesces spontaneously, and at length becomes strongly acid, assuming a blueish colour and a turbid appearance. At last it deposits a sediment, and resumes its transparency, but forms at the same time a thin and mouldy pellicle on the surface.

---

* Exper. par Coulomb. Jour. de Phys. vol. xlix. p. 392.

If exposed to the action of fire it emits bubbles of carbonic acid gas, exhales a strong odour of vinegar, and yields by distillation carbonate of ammonia. Its charcoal contains carbonate of potass, carbonate of lime, and muriate and sulphate of potass. It combines in all proportions with water, which dilutes and dissolves it when thick and viscid. Strong acids deprive it of the carbonic acid and acetous acid which it contains, and occasion the formation of carbonate of lime and acetate of potass which it previously held in solution. Alkalies combine with it readily, and saturate its excess of acid. They resist its tendency to spontaneous decomposition, and retain in solution its extract.*

But the best account of the properties of the sap, and the most complete set of experiments on the subject, are those of Deyeux and Vauquelin. Deyeux analyzed the sap of the Vine and Elm, and found in it acetate of lime, acetous acid, and an extract to which he attributed the formation of ammonia, and the spontaneous precipitation of the sap when left exposed to the action of the air. But the analysis of Vauquelin was more minute. In the sap of *Fagus sylvatica* he found the following ingredients: Water, acetate of lime, with excess of acid, acetate of potass, gallic acid, tannin, mucous, and extractive matter, and acetate of alumina. In 1039 parts of the sap of *Ulmus campestris* he found 1027 parts of water and volatile matter, 9·240 of acetate of potass, 1·060 of vegetable matter, 0·796 of carbonate of lime, besides some slight indications of the presence of sulphuric and muriatic acids; and at a later period of the season he found the vegetable matter increased, and the carbonate of lime and acetate of potass diminished.*

---

* Systême des Connais. vol. viii. p. 130.

Composition and use.

From the above experiments, therefore, as well as from those of other chemists, it is plain that the sap consists of a great variety of ingredients, differing in different species of plants; though there is too little known concerning it to warrant the deduction of any general conclusions, as the number of plants whose sap has been hitherto analysed is yet but very limited. It is the grand and principal source of vegetable aliment, and may be regarded as being somewhat analogous to the blood of animals. It is not made use of by man, at least in its natural state. But there are trees, such as the Birch, whose sap may be manufactured into a very pleasant wine;

---

* Ann. de Chim. vol. xxxi. p. 20.

and it is well known that the sap of the American Maple-tree yields a considerable quantity of sugar.

SECTION XXIV.

The Proper Juice.

How distinguished from the sap.

WHEN the sap has received its last degree of elaboration from the different organs through which it has to pass, it is converted into a peculiar fluid called the Proper Juice. This fluid may be distinguished from the sap by means of its colour, which is generally green, as in Periwinkle; or red, as in Logwood; or white, as in Spurge; or yellow, as in Celandine; from the two last of which it may readily be obtained by breaking the stem asunder, as it will then exude from the fracture. Its principal seat is in the bark, where it occupies the simple tubes; but sometimes it is situated between the bark and wood, as in the Juniper-tree; or in the leaf, as in the greater part of herbs; or it is diffused throughout the whole plant, as in the Fir and Hemlock; in which case, either the proper juice mixes with the sap, or the vessels containing it have ramifications so fine as to be altogether imperceptible. It is not however the same in all plants, nor even in the different parts of the same plant. In the Cherry-tree it is mucilaginous; in the Pine it is resinous; in Spurge and Celandine it is caustic, though resembling in appearance an emulsion. In many plants the proper juice of the bark is different from that of the flower; and the proper juice of the fruit different from both. Its appearance under the microscope, according to Senebier, is that of an assemblage of small globules connected by small and prism-shaped substances placed between them.*

Properties.

If this juice could be obtained in a state of purity, its analysis would throw a considerable degree of light upon the subject of vegetation. But it seems impracticable to extract it without a mixture of sap. Senebier analysed the milky juice of *Euphorbia Cyparissias*, of which he had procured a small quantity considerably pure, though its pungency was so great as to occasion an inflammation of the eyes to the person employed to procure it. It mixed readily with water, to which it communicated its colour. When left exposed to the air a slight precipitation ensued; and when allowed to evaporate a thin and opaque crust remained behind. Alcohol coagulated it into small globules. Ether dissolved it entirely, as did also oil of turpentine. Sulphuric acid changed its colour to black; nitric acid to green.† The most accurate experiments on the subject are those of Chaptal. When oxymuriatic acid was poured into the peculiar juice of *Euphorbia*, a very copious white precipitate fell down, which when washed and dried had the appearance of starch, and was not altered by keeping. Alcohol, aided by heat, dissolved two thirds of it, which the addition of water again precipitated. They had all the properties of resin. The remaining third part possessed the properties of woody fibre. The same experiment was tried on the juice of a variety of other plants, and the result uniformly was that oxymuriatic acid precipitated from them woody fibre.*

---

* Phys. Veg. vol. ii. p. 361.

† Ibid. p. 355.

The virtues of plants have generally been thought to reside in their proper juices, and the opinion seems indeed to be well founded. It is at least proved by experiment in the Poppy, Spurge, and Fig. The juice of the first is narcotic, of the two last corrosive. The diuretic and balsamic virtues of the Fir reside in its turpentine, and the purgative property of Jalap in its resin. If sugar is obtained from the sap of the Sugar-cane and Maple, it is only because it has been mixed with a quantity of proper juice. The bark certainly contains it in greatest abundance, as may be exemplified in Cinnamon and *Quinquina*. But the Peach-tree furnishes an exception to this rule: its flowers are purgative, and the whole plant aromatic; but its gum is without any distinguished virtues.

Malpighi regarded the proper juice as the principle of nourishment, and compared it to the blood of animals; but this analogy does not hold very closely. The sap is perhaps more analogous to the blood, from which the proper juice is rather a secretion. In one respect, however, the analogy holds good, that is, with regard to extravasated blood and peculiar juices. If the blood escapes from the vessels it forms neither flesh nor bones, but tumours; and if the proper juices escape from the vessels containing them they form neither wood nor bark, but a lump or deposite of inspissated fluid.

---

* Ann. de Chim. vol. xxi. p. 285.

To the sap or to the proper juice, or rather to a mixture of both, we must refer such substances as are obtained from plants under the name of expressed juices, because it is evident that they can come from no other source. In this state they are generally obtained in the first instance whether with a view to their use in medicine or their application to the arts. It is the business of the chemist or artist to separate and purify them afterwards according to the peculiar object he may happen to have in view, and the use to which he purposes to apply them. They contain, like the sap, acetate of potass or of lime, and assume a deeper shade of colour when exposed to the fire or air. The oxymuriatic acid precipitates from them a coloured and flaky substance as from the sap, and they yield by evaporation a quantity of extract. But they differ from the sap in exhibiting no traces of tannin or gallic acid, and but rarely of the saccharine principle.

SECTION XXV.

Ashes.

When vegetables are burnt in the open air the greatest part of their substance is evaporated during the process of combustion; but ultimately there remains behind, a portion which is altogether incombustible, and incapable of being volatilized by the action of fire. This residuum is known by the name of ashes.

They exhibit a sort of flaky appearance, of a whitish colour, soft to the touch, and crumbling between the fingers into an impalpable powder. They are without taste and without smell.

Quantity obtained from different plants.

They may be obtained from all parts of the plant, but in different quantities from any given weight, not only in different plants but in different parts of the same plant. Herbaceous plants, after being dried, yield more ashes than woody plants;[*] the leaves more than the branches; and the branches more than the trunk.[†] The alburnum yields also more ashes than the wood; and putrefied vegetables yield more ashes than the same vegetables in a fresh state, if the putrefaction has not taken place in a current of water.[‡] The result of Saussure's experiments on this subject was the following:

[*] Kirwan, Irish Trans. vol. v. p. 164.

[†] Ann. de Chim. vol. xix. p. 178.

[‡] Saussure, chap. ix.

A thousand parts of dried leaves of the Oak gathered in May contained 53 parts of ashes; of the *Rhododendrum ferrugineum*, 30.

A thousand parts of the leaves of the *Æsculus Hypocastanum* gathered in May yielded 72 parts of ashes; of the trunk and branches, 35.

A thousand parts of the leaves of the same plant gathered in September, 86 parts of ashes; the fruit gathered in October, 34.

A thousand parts of the dried bark of the Oak contained 60 parts of ashes; of the alburnum, four; of the wood, two.

A thousand parts of the leaves of the Oak gathered in May yielded in the green state 13 parts of ashes, dried, 53. The same leaves gathered in September yielded in their green state 24 parts of ashes, dried, 55.

A thousand parts of the *Pisum sativum* in flower yielded 95 parts of ashes; when in fruit, only 81.

A thousand parts of the *Vicca faba* yielded before flowering 16 parts of ashes in their green state, and 895 parts of water of vegetation; when in flower they contained 20 parts of ashes and 876 of water of vegetation.

Such are the proportions in which plants, when decomposed by combustion, yield ashes, as far as these proportions have been ascertained by the experiments of Saussure. But a more important subject of inquiry is the analysis of the ashes themselves, with a view to the discovery of the ingre- Composition.

dients of which they are composed. These may be reduced to three, alkalies, earths, and metals, which must therefore be considered as ingredients in the composition of the vegetable. But vegetable ashes contain also a variety of other principles, occurring, however, in such small proportions as generally to escape observation. Perhaps they contain all substances not capable of being volatilized by the action of fire.

SECTION XXVI.

Alkalies.

Whence obtained. THE alkalies are a peculiar class of substances, distinguished by a caustic taste and the property of changing vegetable blues to green. They are generally regarded as being three in number, potass, soda, and ammonia, of which the two former only are found in the ashes of vegetables. Ammonia is, indeed, often obtained from vegetable substances by means of distillation, but then it is always formed during the process.

Potass. If the ashes of vegetables burnt in the open air are repeatedly washed in water, and the water filtered and evaporated to dryness, potass is left behind. The potass of commerce is manufactured in this manner, though it is not quite pure. But it may be purified by dissolving it in spirits of wine, and evaporating the solution to dryness in a silver vessel.

When pure it is white and semi-transparent, and is extremely caustic and deliquescent. It dissolves all soft animal substances, and changes vegetable blues into green. It dissolves alumina, and also a small quantity of silex, with which it fuses into glass by the aid of fire. It had been long suspected by chemists to be a compound substance; and according to the notable discovery of Sir H. Davy, its component parts are at last ascertained to be a highly inflammable metal, which he denominates potassium, and oxygene—one proportion of each.*

Soda is found chiefly in marine plants, from the ashes of which it is obtained by means of lixiviation. It exists in great abundance in *Salsoa Soda*, *Zostera maritima*, and in various species of *Fuci*. It is generally obtained in the state of a carbonate, but is purified in the same manner as potass, to which it is similar in its properties; but from which it is easily distinguished by its forming a hard soap with oil, while potass forms a soft soap. It consists, according to Sir H. Davy, of one proportion of a metal which he denominates sodium, and two proportions of oxygene.†

Soda.

Such are the only vegetable alkalies, and the modes of obtaining them. They are found generally in the state of carbonates, sulphates, or muriates, salts that form beyond all comparison the most abundant ingredient in the ashes of green herbaceous plants whose parts are in a state of vegetation.

---

* Elem of Agri. Chem. p. 98. † Ibid.

The ashes of the Golden Rod growing in an uncultivated soil, and of the Bean, Turnsol, and Wheat, were found by Saussure to contain at least three-fourths of their weight of Alkaline salts. This was nearly the case also with the leaves of trees just bursting from the bud. But the proportion of alkaline salts is found to diminish rather than to augment as the parts of the plant are developed. The ashes of the leaves of the Oak gathered in May yielded 47 parts in the 100 of alkaline salts; and in September, only 17.*

Uses. The utility of the alkalies, as obtained from vegetables, is of the utmost importance in the arts, particularly in the formation of glass and of soaps. If a mixture of soda or potass, and silex or sand, in certain proportions, is exposed to a violent heat, the ingredients are melted down into a fluid mass, which is glass in a state of fusion. In this state it may be moulded into almost any form at the pleasure of the artist. And accordingly we find that it is manufactured into a great variety of utensils and instruments under the heads of *flint-glass*, *crown-glass*, *bottle-glass*. Bottle-glass is the coarsest: it is formed of soda and common sand, and is used in the manufacture of the coarser sort of bottles. Crown-glass is composed of soda and fine sand: it is moulded into large plates for the purpose of forming window-glasses and looking-glasses. Fint-glass is the finest and most transparent of all: that which is of the best quality is composed of 120 parts of white siliceous sand, 40 parts of pearl-ash, 35 of red oxide of lead, 13 of nitrate of potass, and 25 of black oxide of manganese.* It is known also by the name of crystal, and may be cut and polished so as to serve for a variety of ornamental purposes, as well as for the more important and more useful purpose of forming optical instruments, of which the discoveries of the telescope and the microscope are the curious or sublime results.

---

* Saussure sur la Vegetation, chap. ix. sect. iv.

If a quantity of oil is mixed with half its weight of a strong solution of soda or potass, a combination takes place which is rendered more complete by means of boiling. The new compound is soap. The union of oil with potass forms soft soap, and with soda hard soap; substances of the greatest efficacy as detergents, and of the greatest utility in the washing and bleaching of linen.

The alkalies are used also in medicine, and are found to be peculiarly efficacious in the reduction of urinary calculi.

SECTION XXVII.

Earths.

THE only earths which have hitherto been found in plants are the following: lime, silica, magnesia, alumina. 1st, *Lime.*—Of these earths, lime is by far the most abundant. It is generally combined with a portion of phosphoric, carbonic, or sulphuric acid, forming phosphates, or carbonates, or sulphates of lime.

---

* Accum's Chemistry, vol. ii. p. 194.

Found in the state of salts.

The phosphate of lime is, next to the alkaline salts, the most abundant ingredient in the ashes of green herbaceous plants whose parts are all in a state of vegetation.* The leaf of a tree bursting from the bud contains in its ashes a greater proportion of earthy phosphate than at any other period: 100 parts of the ashes of the leaves of the Oak gathered in May furnished 24 parts of earthy phosphate; in September, only 18·25. In annual plants the proportion of earthy phosphate diminishes from the period of their germination to that of their flowering. Plants of the Bean, before flowering, gave 14·5 parts of earthy phosphate; in flower, only 13·5.

Carbonate of lime is, next to phosphate of lime, the most abundant of the earthy salts that are found in vegetables. But if the leaves of plants are washed in water the proportion of carbonate is augmented. This is owing to the substraction of their alkaline salts and phosphates in a greater proportion than their lime. In green herbaceous plants whose parts are in a state of increase, there is but little carbonate of lime; but the ashes of the bark of trees contain an enormous quantity of carbonate of lime, and much more than the alburnum, as do also the ashes of the wood. The ashes of most seeds contain no carbonate of lime; but they abound in phosphate of potass. Hence the ashes of plants, at the period of the maturity of the fruit, yield less carbonate of lime than at any previous period.*

---

* Saussure sur la Vegetation.

2dly, *Silica.*—Silica is not found to exist in a great proportion in the ashes of vegetables, unless they have been previously deprived of their salts and phosphates by washing; but when the plants are washed in water the proportion of their silica augments. The ashes of the leaves of the Hazel gathered in May yielded 2·5 parts of silica in 100. The same leaves washed yielded four parts in 100.

Young plants and leaves bursting from the bud contain but little of silica in their ashes; but the proportion of silica augments as the parts are developed. But perhaps this is owing to the diminution of the alkaline salts. The ashes of some stalks of Wheat gathered a month before the time of flowering, and having some of the radical leaves withered, contained $\frac{12}{100}$ of silica and $\frac{65}{100}$ of alkaline salts. At the period of their flowering, and when more of their leaves were withered, the ashes contained 32 parts of silica and 54 of alkaline salts.

Seeds divested of their external covering contain less silica than the stem furnished with its leaves; and it is somewhat remarkable that there are trees of which the bark, alburnum, and wood, contain scarcely any silica, and the leaves a great deal, par-

* Saussure sur la Vegetation, chap. ix. sect. vi.

ticularly in autumn.* This is a phenomenon that seems inexplicable.

The greater part of the Grasses contain a very considerable proportion of silica, as do also the plants of the genus *Equisetum*. Sir H. Davy has discovered that it forms a part of the epidermis of these plants, and in some of them the principal part. From 100 parts of the epidermis of the following plants the proportions of silica were as follows:

Bonnet Cane	90
Bamboo	71·4
Common Reed	48·1
Stalks of Corn	66·5

Owing to the silica contained in the epidermis, the plants in which it is found are sometimes used to give a polish to the surface of substances where smoothness is required. The Dutch Rush, a plant of this kind, is used to polish even brass.

3dly, *Magnesia.*—Magnesia does not exist so abundantly in the vegetable kingdom as the two preceding earths. It has been found, however, in several of the marine plants, particularly the *Fuci*; but *Salsola Soda* contains more of magnesia than any other plant yet examined. According to Vauquelin 100 parts of it contain 17·929 of magnesia.

4thly, *Alumina.*—Alumina has been detected in several plants, but never except in very small quantities.

---

* Saussure sur la Vegetation.

SECTION XXVIII.

Metallic Oxides.

Occur in small quantities.

AMONG the substances found in the ashes of vegetables we must class also metals. They occur however only in small quantities, and are not to be detected except by the most delicate experiments.

The metals hitherto discovered in plants are iron, manganese, and perhaps gold. Of these iron is by far the most common. It occurs in the state of an oxide, and the ashes of hard and woody plants, such as the Oak, are said to contain nearly $\frac{1}{12}$ part of their own weight of this oxide.* The ashes of *salsola* contain also a considerable quantity.

The oxide of manganese was first detected in the ashes of vegetables by Scheele, and afterwards found by Proust in the ashes of the Pine, *Calendula,* Vine, Green Oak, and Fig-tree.†

Beccher, Kunckel, and Sage, together with some other chemists, contend also for the existence of gold in the ashes of certain plants; but the very minute portion which they found seems more likely to have proceeded from the lead employed in the process than from the ashes of the plant.

---

* Fourcroy, vol. viii. p. 203.

† Thomson's Chemistry, vol. iv. p. 357.

It has been observed by Saussure that the proportion of the oxides of iron and of manganese augments in the ashes of plants as their vegetation advances. The leaves of trees furnish more of these principles in autumn than in spring. It is so also with annual plants. Seeds contain metals in less abundance than the stem; and if plants are washed with water the proportion of their metallic oxides is augmented.

SECTION XXIX.

General Remarks.

The substances that have been above described constitute, as is evident, the principal ingredients that enter into the vegetable composition. They are indeed numerous, though some of them, such as the metallic oxides, occur in such small proportions as to render it doubtful whether they are in reality vegetable productions or no. The same thing may be said of some of the other ingredients that have been found in the ashes of plants, which it is probable they have absorbed ready formed by the root, and deposited unaltered, so that they can scarcely be at all regarded as being the genuine products of vegetation.

But besides the substances above enumerated there are also several others that have been supposed to constitute distinct and peculiar genera of vegetable productions, and which might have been introduced under such a character; such as the mucus, jelly, sarcocol, asparagin, inulin, and ulmin, of Dr. Thomson, as described in his well known System of Chemistry; but as there seems to be some difference of opinion among chemists with regard to them, and a belief entertained that they are but varieties of one or other of the foregoing ingredients,* it is sufficient for the purposes of this work to have merely mentioned their names.

Several other substances of a distinct and peculiar character have been suspected to exist, and may very possibly exist, in vegetable productions: such as the febrifuge principle of Seguin, as discovering itself in Peruvian Bark; the principle of causticity or acridity of Senebier,† as discovering itself in the roots of *Ranunculus bulbosus, Scilla maritima, Bryonia alba*, and *Arum maculatum*, in the leaves of *Digitalis purpurea*, in the bark of *Daphne Mezereon*, and in the juice of the Spurges: to which may be added the fluid secreted from the sting of the common Nettle, the poisons inherent in some plants, and the medical virtues inherent in others; together with such peculiar principles as may be presumed to exist in such regions of the vegetable kingdom as remain yet unexplored. The important discoveries which have already resulted from the chemical analysis of vegetable substances encourage the hope that further discoveries will be the result of further experiment; and from the zeal and ability of such chemists as are now directing their attention to the subject every thing is to be expected.

---

* Elem. of Agri. Chem. p. 104.

† Phys. Veg. vol. ii. p. 408.

CHAPTER II.

SIMPLE PRODUCTS.

FROM the analysis of the vegetable subject as exhibited in the foregoing chapter, it is evident that the compound ingredients of vegetables are all ultimately reducible to a very few constituent and uncompounded elements; and that the most essential of such compounds consist of carbon, oxygene, and hydrogene, merely; though others contain also a small proportion of nitrogene said to be found only in cruciform plants. The remaining elementary principles which plants have been found to contain, although they may be necessary in the vegetable economy, yet they are by no means principles of the first importance, as occurring only in small proportions, and being dependant in a great measure on soil and situation; whereas the elements of carbon, oxygene, and hydrogene, form as it were the very essence of the vegetable subject, and constitute by their modifications the peculiar character of the properties of the plant.

This is conspicuously exemplified in the result of the investigations of Messrs. Gay Lussac, and

Thenard, who have deduced from a series of the most minute and delicate experiments the three following propositions, which they have dignified by the name of laws of vegetable nature:*

1st, Vegetable substances are always acid when the oxygene they contain is to the hydrogene in a greater proportion than in water.

2dly, Vegetable substances are always resinous, or oily, or spirituous, when the oxygene they contain is to the hydrogene in a smaller proportion than in water.

3dly, Vegetable substances are neither acid nor resinous, but saccharine or mucilaginous, or analogous to woody fibre or starch, when the oxygene and hydrogene they contain are in the same proportion as in water.

Perhaps the induction of particular proofs is not yet sufficiently complete to warrant the above conclusions in their utmost extent. But enough has been established, by the above or by other chemists, to satisfy the scientific inquirer that the closest analogy exists between several compounds that differ widely in their sensible qualities; as well as to elucidate several processes in nature and art by which certain vegetable substances are convertible into one another. And hence an additional proof of the great power and wisdom of the Creator, who, from a few simple and primary elements combined in peculiar proportions, educes all that variety and profusion of compound substances which the vegetable kingdom exhibits as adapted to the wants of man.

---

* Traité de Chem. Element. tom. iii. chap. iii.

Such is the brief sketch of the vegetable analysis which I have thought it expedient to introduce into the present work. But if the reader, not being already an adept, wishes to descend into the detail of particulars and to prepare himself for original experiment, let him search out and peruse original papers, and let him consult the vegetable department of the several elementary publications referred to in this book, especially that of Dr. Thomson's System of Chemistry; the most distinguished and elaborate of all our elementary works on the subject, and the guide I have chiefly applied to in the drawing up of the sketch that is here exhibited.

END OF VOL. I.

HALLIDIE LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

C. Baldwin, Printer,
New Bridge-street, London.

SCIENTIFIC BOOKS

PUBLISHED BY

BALDWIN, CRADOCK, AND JOY.

ANNALS of PHILOSPHY; or, Magazine of Chemistry, Mineralogy, Mechanics, Natural History, Agriculture, and the Arts. By Thomas Thomson, M.D. F.R.S. &c.

⁂ This Work is published monthly in Numbers, Price 2*s.* 6*d.* each. It commenced in January 1813; and has been constantly enriched by the valuable Contributions of scientific Foreigners, as well as by the first Philosophers of our own country.

THE HISTORY of the ROYAL SOCIETY, from its Institution to the present Time. By the same Author, in 4to. Price 2*l.* 2*s.* On large paper 3*l.* 12*s.*

A SYSTEM of CHEMISTRY. By the same Author. In Five Volumes, 8vo. 3*l.* 15*s.*

TRAVELS in SWEDEN during the Autumn of 1812, with an Account of Lapland. By the same Author. Illustrated by Maps, Portraits, and other Plates, 4to. 2*l.* 2*s.*

ELEMENTS of PRACTICAL CHEMISTRY. By William Henry, M.D. F.R.S. The seventh Edition, greatly enlarged; and illustrated with nine Plates, engraved by Lowrie, in boards, 8vo. Price 1*l.* 8*s.*

CHEMICAL ESSAYS, on various Subjects, principally relating to the Improvement of the Arts and Manufactures of the British Dominions. By Samuel Parkes, F.L.S. Member of the Geological Society, and Proprietor of the Chemical Manufactory, in Goswell-street. Neatly printed in Five Pocket Volumes, with 23 Engravings, Price 2*l.* 2*s.* extra boards.

THE CHEMICAL CATECHISM, with Notes, Illustrations, and Experiments. By the same Author. The seventh Edition, with very considerable Emendations and Additions, in 8vo. Price 12*s.*

THE PHYSIOGNOMICAL SYSTEM of Drs. Gall and Spurzheim; founded on an Anatomical and Physiological Examination of the Nervous System in general, and of the Brain in particular; and indicating the Dispositions and Manifestations of the Mind. By J. G. Spurzheim, M.D. In royal 8vo. Price 1*l.* 10*s.* with 19 Copper-plates, the second Edition, with Additions.

SCIENTIFIC BOOKS.

HARMONIES of NATURE. By J. B. H. De St. Pierre, Author of Studies of Nature, Paul and Virginia, &c. translated from the French by W. Meston, A.M. in Three Volumes 8vo. Price 1*l.* 16*s.* with a Portrait of the Author.

CURSORY Remarks on the Physical and Moral History of the HUMAN SPECIES, and its Connexions with surrounding Agency. By L. S. Boyne. In One Volume, 8vo. Price 10*s.* 6*d.* boards.

RESEARCHES ABOUT ATMOSPHERIC PHENOMENA. By Thomas Forster, F.L.S. The second Edition, greatly enlarged, in 8vo. Price 10*s.* 6*d.*

*** This Edition contains a Series of Plates, illustrative of Mr. Howard's Nomenclature of the Clouds and other Atmospheric Phenomena. The want of such a Nomenclature has rendered all descriptions of Atmospheric appearances unintelligible or indistinct. It is hoped, therefore, that this attempt to lay down some general rules for Observers may be found extremely advantageous to the Painter and Engraver.

ESSAY on the THEORY of the EARTH; translated from the French of M. Cuvier, Perpetual Secretary of the French Institute, Professor and Administrator of the Museum of Natural History, &c. By Robert Kerr, F.R.S. and F.A.S. Edin. With Mineralogical Notes, and an Account of Cuvier's Geological Discoveries. Second Edition, considerably enlarged, by Professor Jameson. 8vo. Price 10*s.*

An ATTEMPT to establish a PURE SCIENTIFIC SYSTEM of MINERALOGY, by the Aplication of the Electro-Chemical Theory, and the Chemical Proportions. By J. Jacob Berzelius, M.D. F.R.S. Professor of Chemistry at Stockholm. Translated from the Swedish Original, by John Black. In One small Volume 8vo. Price 6*s.*

ROYAL SOCIETY.

Messrs. BALDWIN, CRADOCK *and* JOY, *having purchased of the original Proprietors all the remaining Copies of THE PHILOSOPHICAL TRANSACTIONS, abridged by* DR. HUTTON, DR. SHAW, *and* DR. PEARSON, *in* 18 *vols. 4to., have determined to offer them to the Public for a limited time at the following reduced prices. viz.*

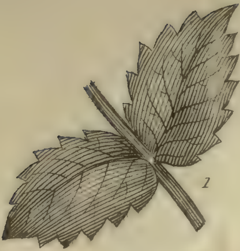
The Demy Paper, at £18 18*s.* originally published at £38 6*s.* 6*d.*
The Royal Paper,....31 10*s.*....................... 64 16 0

*** In conducting this work it was the object of the Editors to form, as completely as possible, a substitute for the *original*, now no longer, or very rarely, to be procured. With this view they were extremely sparing in curtailment, the thickness of the volumes, and the close manner in which they are printed, enabling them to retain a very large proportion of the Transactions at large from their commencement in 1665 to the year 1800. Of even the few papers whose substance has been omitted, the titles are retained, with references to the volume and page of the original work; so that by means of a *Copious Index* contained in the 18th volume, the place of every paper in the original may be referred to. The work is enriched by 268 copper-plates full of figures, no expence having been spared to render it as perfect as possible. To each volume there are two Tables of Contents, one corresponding with the Number as printed; the other exhibiting the different subjects classed under their respective heads.

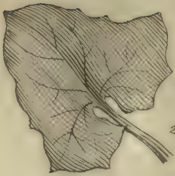
Gentlemen may procure the work, on the terms above stated, through the medium of their respective booksellers, or by application at 47, Paternoster Row, London.

UNIVERSITY

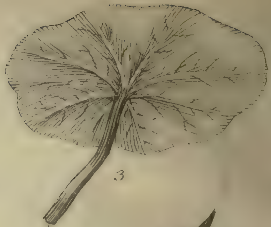
OF
UNIVERSITY



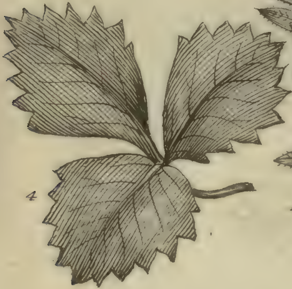
1



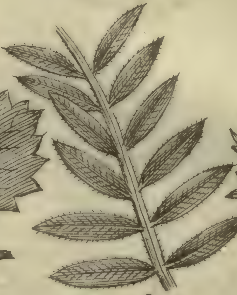
2



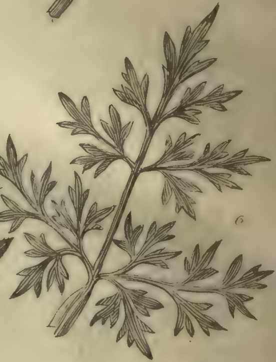
3



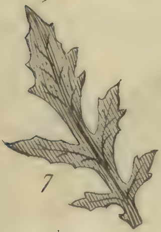
4



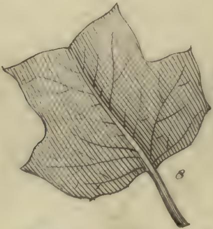
5



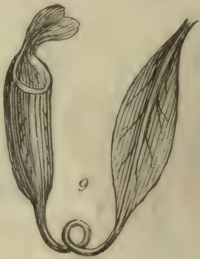
6



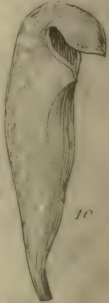
7



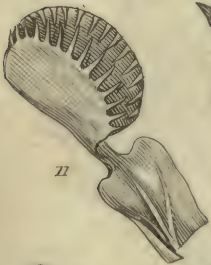
8



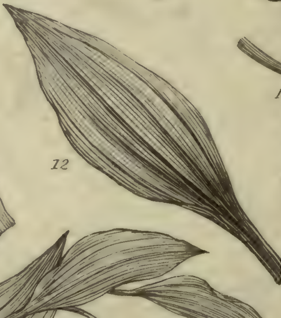
9



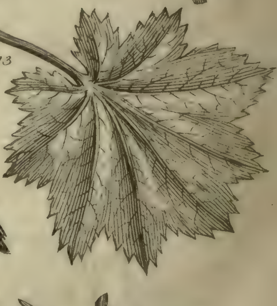
10



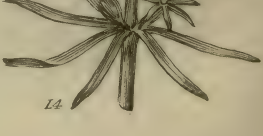
11



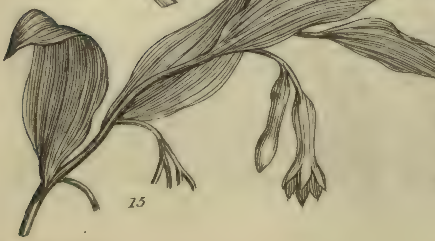
12



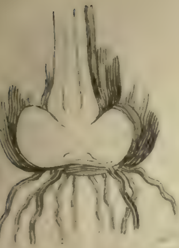
13

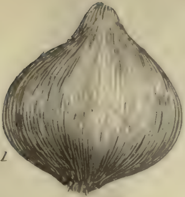


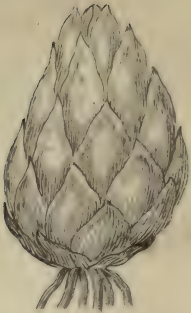
14

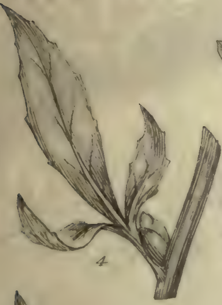


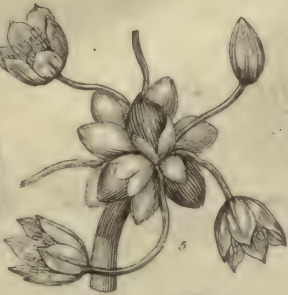
15

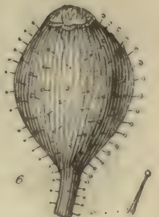

2

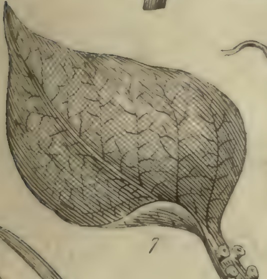

1

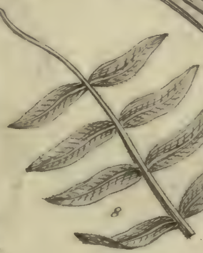

3

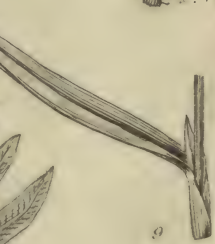

4

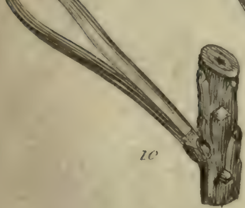

5

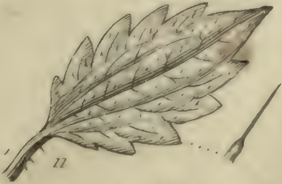

6

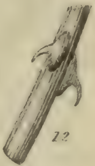

7

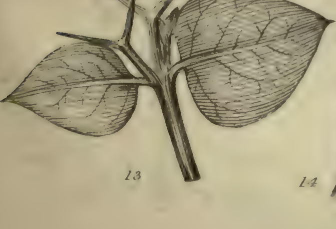

8

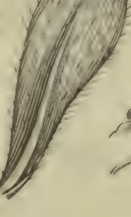

9

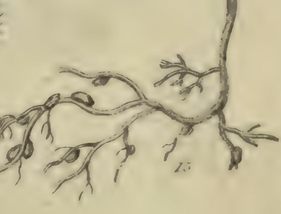

10


11


12


13


14

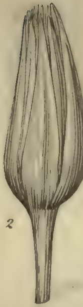

15

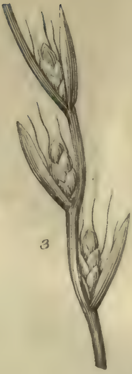
by Baldwin, Cradock & Joy, Jan. 1, 1816

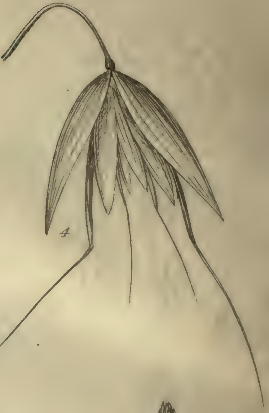
UNIVERSITY
OF
CALIFORNIA

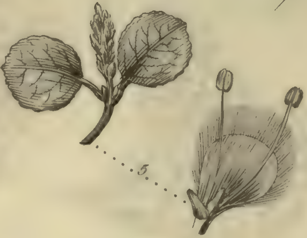
UNIVERSITY
OF
CALIFORNIA

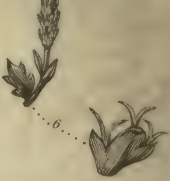
1

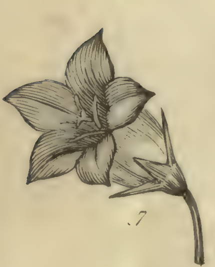

2

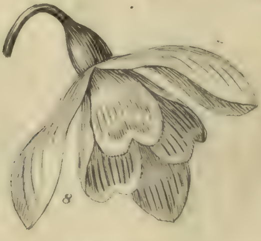

3

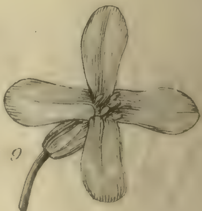

4

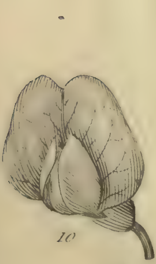

5

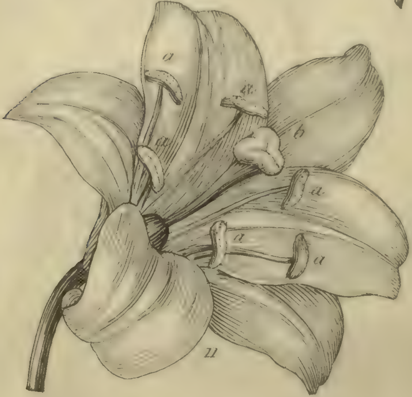

6


7

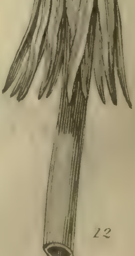

8


9

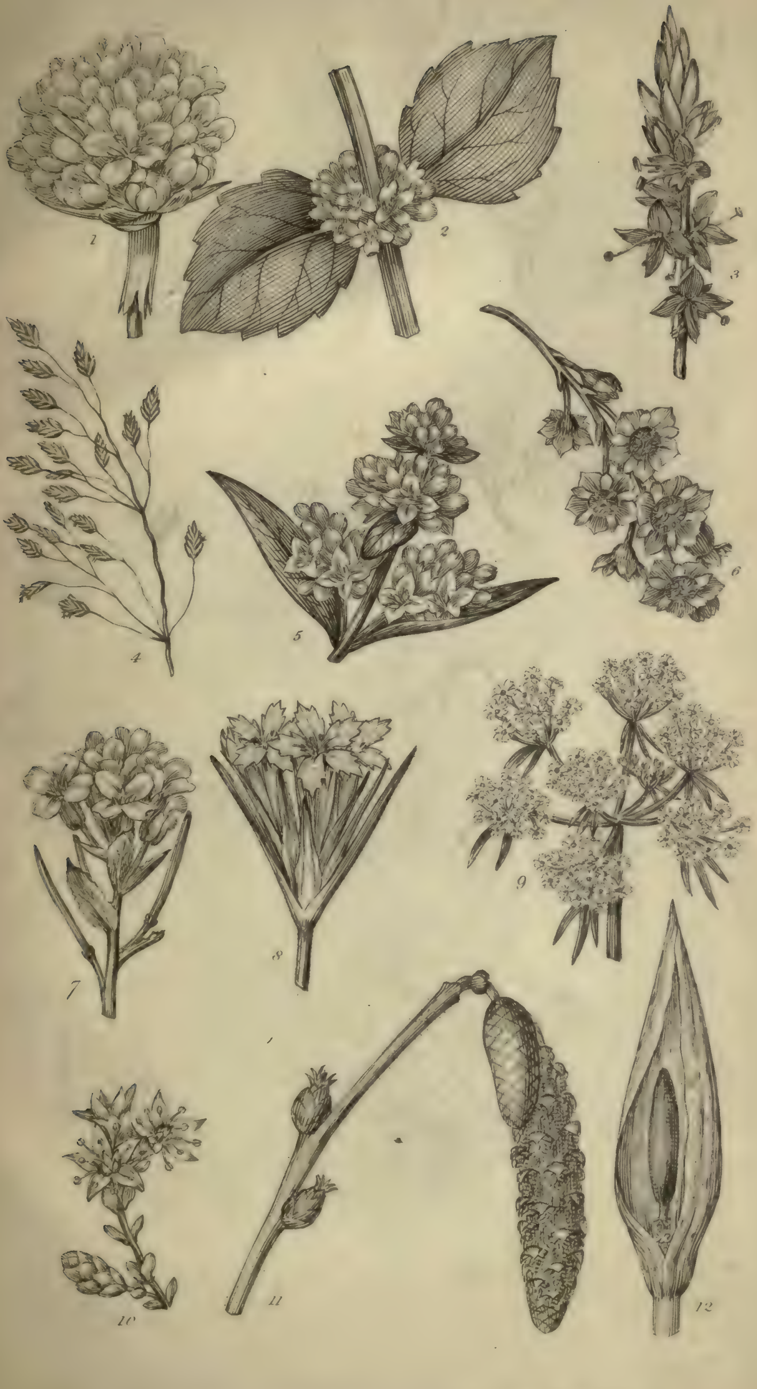

10



11


12

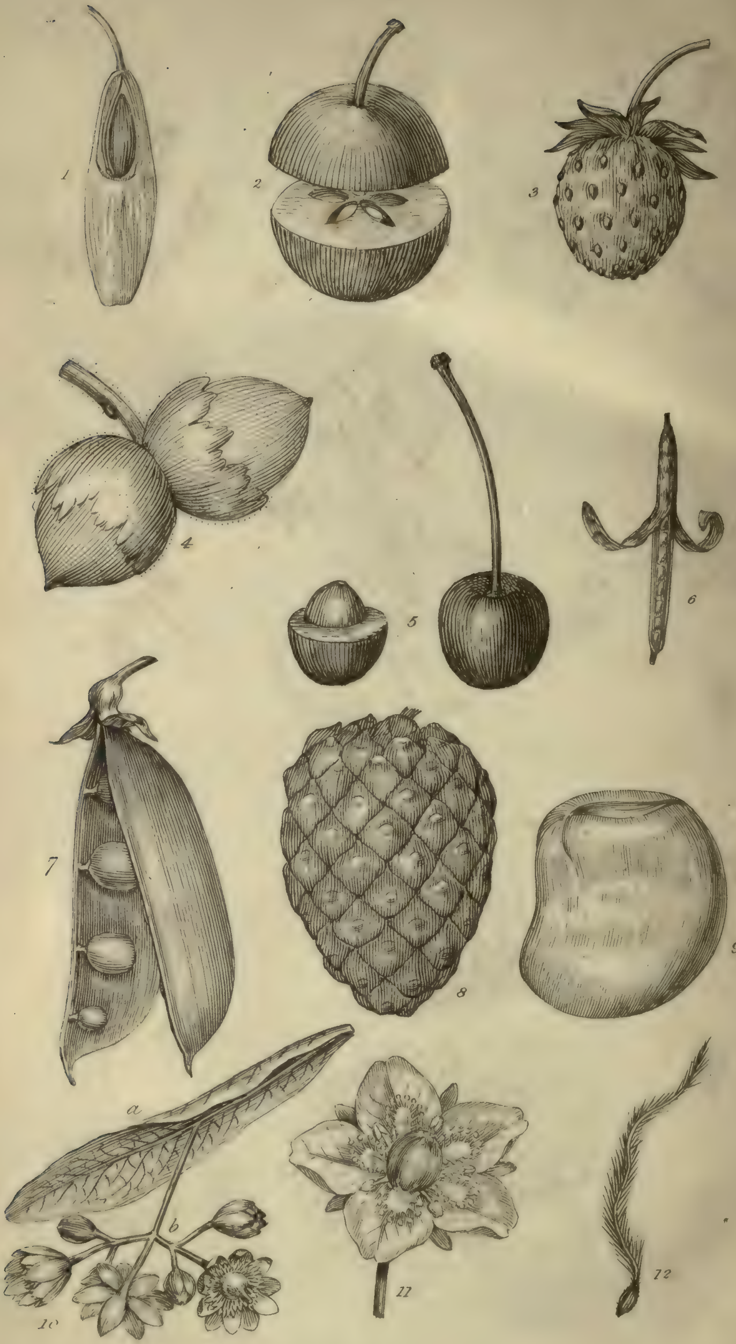
Drawn & Engraved by Sowerby: for Baldwin, Cradock & Joy, April. 1816.


1
2
3
4
5
6
7
8
9
10
11
12

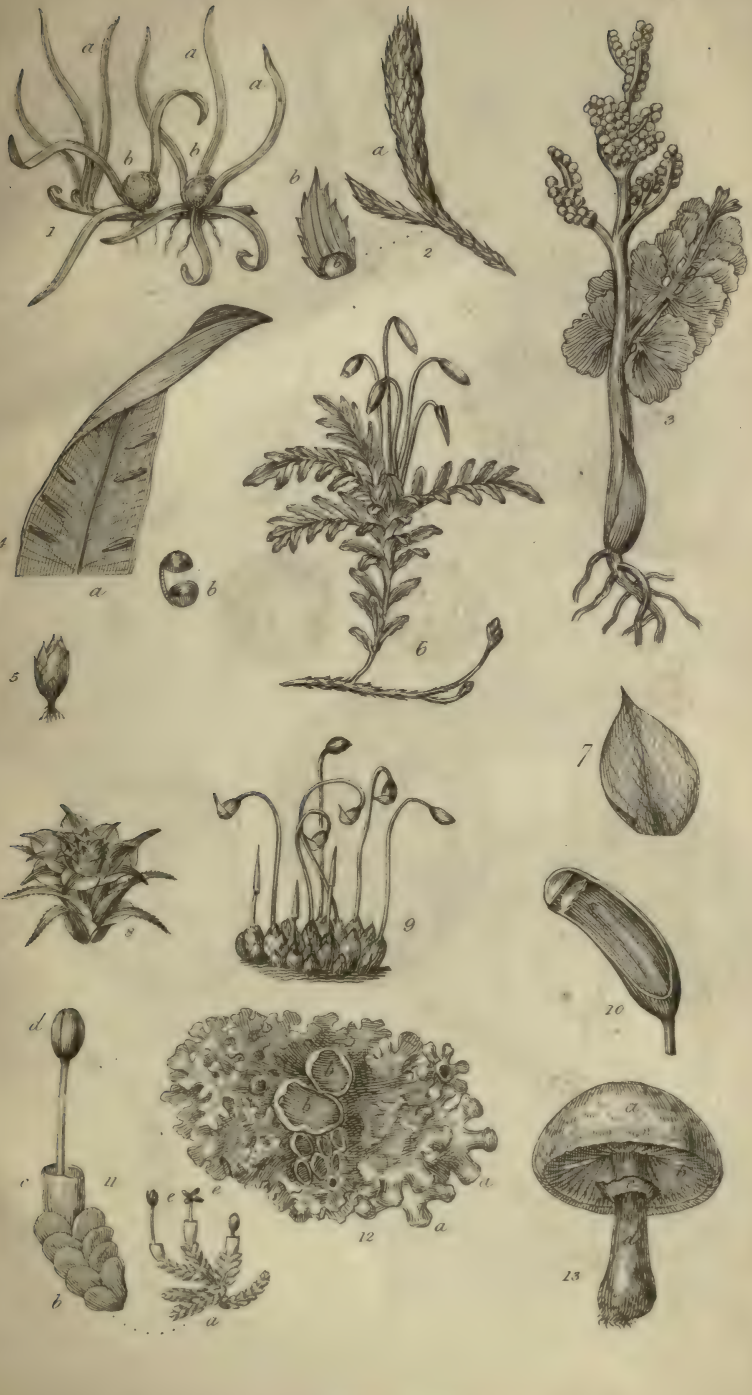
Drawn & Engraved by Sowerby for Baldwin, Cradock & Joy. April. 1816.

OF THE
UNIVERSITY
CALIFORNIA

[illegible] LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA


1
2
3
4
5
6
7
8
9
a
b
10
11
12

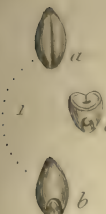
Drawn & Engraved by Sowerby, for Baldwin, Cradock & Joy, April, 1816.

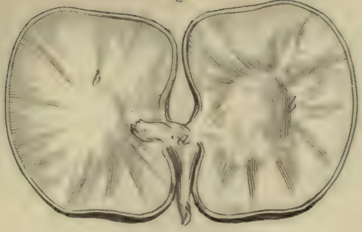

a
a
a
b
b
1
a
b
b
2
3
4
a
b
5
6
7
8
9
10
d
b
b
c
11
e
e
a
b
12
a
a
b
c
d
13

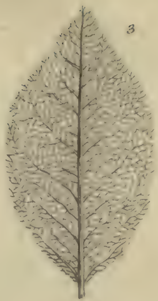
Drawn & Engraved by Sowerby for Baldwin Cradock & Joy April 1816.

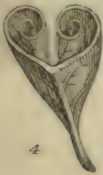
HALLIDIE LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

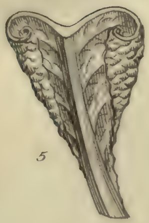
VIII

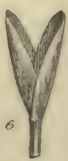

1

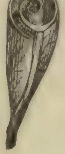

2

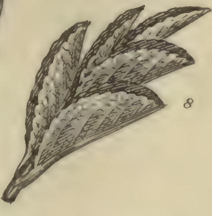

3

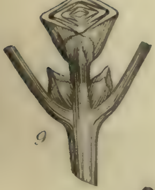

4

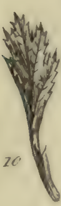

5

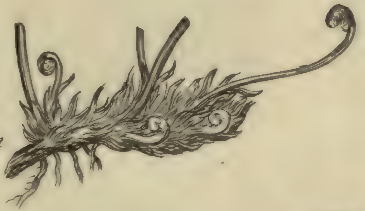

6

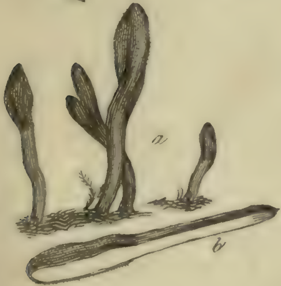

7

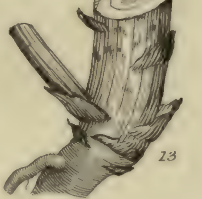

8

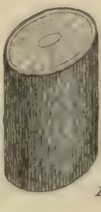

9

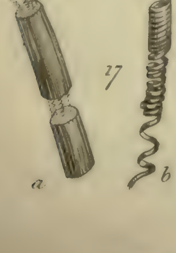

10

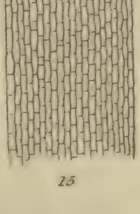

11

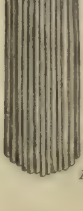

12


13


14


17


15


16

Drawn & Engraved by Sowerby for Baldwin Cradock & Joy April 1816.

[illegible] LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA

UNIVERSITY OF CALIFORNIA LIBRARY,
BERKELEY

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

Books not returned on time are subject to a fine of 50c per volume after the third day overdue, increasing to $1.00 per volume after the sixth day. Books not in demand may be renewed if application is made before expiration of loan period.

OCT 2 1922
NOV 20 1924

APR 4 1930
~~APR~~ 23 1951 lc
MAY 14 1951

20m-1,'22

U.C. BERKELEY LIBRARIES
715

QK711
K42
V.1

103982
Keith

BIOLOGY
LIBRARY
G